SAVITRI SACHDEV

TOURISM AND CLIMATE CHANGE

IMPACTS, ADAPTATION AND MITIGATION (VOLUME I)

Tourism and Climate Change: Impacts, Adaptation and Mitigation (Volume 1)

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Savitri Sachdev
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Tourism and Global Environmental Change: An Overview

Stefan Gössling and C. Michael Hall

Introduction

Tourism is largely dependent on natural resources. For example, the provision of fresh water for drinking, taking showers, swimming pools or the irrigation of hotel gardens seem self-evident preconditions for tourism all around the world. Beaches and coastlines, mountains, forests, lakes, oceans and the scenery provided by landscapes containing these elements are central to the attraction potential of most destinations. Similarly, biodiversity is a tourist magnet in many regions, including a wide variety of bird and fish species, as well as charismatic mammals such as moose or deer, whales, dolphins or the 'big five' (leopard, lion, rhino, elephant, hippopotamus) in national parks in eastern and southern Africa. In mountainous areas, snow cover is a *conditio sine qua non* for winter sports, including skiing, snowboarding, snowmobiling and dog sledding, and many areas would lose their tourist appeal without snow – for instance, what would impressive mountain ranges like the Alps or tropical Mount Kilimanjaro be without their white-covered tops? Clearly, most tourism is based on stable and, for tourism, favourable environmental conditions.

Global environmental change (GEC) threatens these very foundations of tourism through climate change, modifications of global biogeochemical cycles, land alteration, the loss of non-renewable resources, unsustainable use of renewable resources and gross reductions in biodiversity. Elements of the global environment are always changing although change is never uniform across time and space. Nevertheless, 'all changes are ultimately connected with one another through physical and social processes alike' (Meyer and Turner 1995: 304). The scale and rate of change has increased dramatically because of human actions within which tourism is deeply embedded.

Human impacts on the environment can have a global character in two ways. First, 'global refers to the spatial scale or functioning of a system' (Turner *et al.* 1990: 15). Here, the climate and the oceans have the characteristic of a global system and both influence and are influenced by tourism production and consumption. A second kind of GEC occurs if a change 'occurs on a worldwide scale, or represents a significant fraction of the total environmental phenomenon or global resource' (Turner *et al.* 1990: 15–16). Tourism is significant for both types of change.

This volume takes a systematic approach to understanding the environmental, social, economic and political interrelationships of tourism and GEC. In the first section, environmental change in each of the environments of importance for tourism is analysed, including the polar regions, mountains, lakes and streams, forests, coastal zones, islands and reefs, deserts and savannah regions, as well as urban environments. The volume's second section focuses on four aspects of GEC that might become particularly important for tourism: availability of fresh water, existence of diseases, biodiversity, and frequency and intensity of extreme weather events. In the final section, the book discusses issues of adaptation to GEC. Although this is a relatively unexplored research field of great uncertainty, the contributors present options for tourism adaptation in those environments that are likely to face the most rapid environmental changes – mountains – and presents a number of new avenues to the discussion of the consequences of GEC for tourism from sociology and business perspectives.

Tourism development

Any adequate conceptualisation of tourism demands a comprehensive approach that involves the relationships between tourism, leisure and other social practices and behaviours related to human movement (Coles *et al*. 2004; 2005). Such an assessment is necessary in the analysis of contemporary human mobility given the extent to which time-space convergence has made it easier for those with sufficient time and economic budgets to move over time and space. Travel which once took two or three days to accomplish may now be completed as a daytrip. Convergence through physical travel is also complemented by convergence in communications (Janelle and Hodge 2000). Clearly, such shifts in mobility have implications for a wide range of human activities both within and outside of tourism. They can be seen alongside ideas of accessibility, extensibility, distance and proximity, significant elements of global socio-cultural change (Johnston *et al*. 1995), as well as underlying social contributions to tourism related consumption of the environment (Hall 2005a).

The relative lack of interplay and cross-fertilisation between the fields that study human mobility is remarkable (Williams and Hall 2002). This is especially evidenced by the difficulties to be encountered in finding overlap between national and international surveys of tourism and migration, and studies of short- and long-term travel undertaken in transport studies, a factor that also has considerable impact on the understanding of the contribution of tourism to GEC. Nevertheless, as Coles *et al*. (2004) argued, the conceptualisation and development of theoretical approaches to tourism should consider the relationships of tourism to other forms of mobility, including the creation of extended transnational networks that also promote human movement. Figure 1.1 presents a model for describing different forms of temporary mobility in terms of three dimensions of space, time and number of trips. The fact that the number of movements declines the further one travels in time and space away from the point of origin is well recognised in the study of spatial interaction. However, it has not been used as a means to illustrate the totality of trips that are undertaken by individuals.

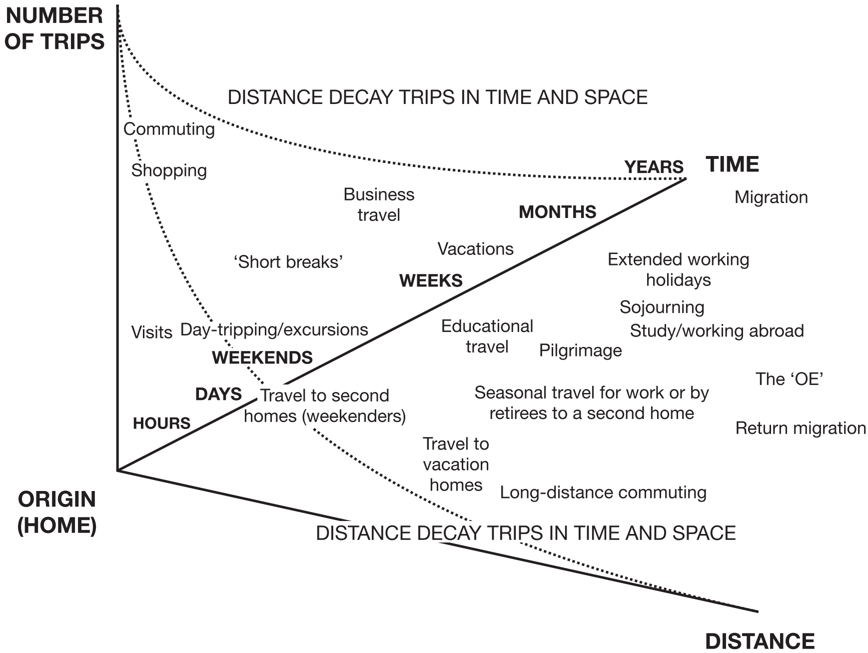

Figure 1.1 Extent of mobility in time and space

Source: after Hall 2003

The relationship represented in Figure 1.1 holds whether one is describing the totality of movements of an individual over their life span from a central point (home), or whether one is describing the total characteristics of a population (Hall 2005a; 2005b). The figure illustrates the relationship between tourism and other forms of temporary mobility including various forms of what is often regarded as migration or temporary migration (Bell and Ward 2000). Such activities, which have increasingly come to be discussed in the tourism literature, include travel for work and international or 'overseas' experiences (e.g. Rosenkopf and Almeida 2003), education (e.g. Field 1999), health (e.g. Goodrich 1994), as well as travel to second homes (e.g. Hall and Müller 2004), return migration (e.g. Duval 2003) and diaspora (e.g. Coles and Timothy 2004). Arguably, some of these categories could be described as 'partial tourists' (Cohen 1974), or even as 'partial migrants', although the amenity or leisure dimension remains important as a motivating factor in their voluntary mobility (Frändberg 1998; Coles *et al*. 2004; Hall 2005a).

Focusing on the range of mobilities also provides an important dimension with respect to the examination of tourism's impacts. Mobilities need to be examined over the duration of the lifecourse, so that the linkages and relationships between different forms of 'temporary' and 'permanent' mobilities, particularly tourism and amenity migration, are better understood. Such a lifecourse approach may also have extremely practical applications in terms of studying how people switch modes of consumption between locations and activities. For example, while people may attempt to be green consumers in one aspect of their life, their consumption may actually increase in others, thereby leading to no net improvement in their overall rate of consumption.

Most research on tourism impacts has also tended to occur at the destination (Lew *et al*. 2004). This has meant that research has often examined local factors rather than the totality of the impact of tourism in time and space by also considering effects at the tourism-generating region, and travel to and from destinations. As significant as destination impacts might be, the study of tourism impacts therefore needs to be undertaken over the totality of the tourism consumption and production system, rather than just at the destination (Bach and Gößling 1996; Frändberg 1998; Høyer 2000; Gössling 2002; Frändberg and Vilhelmson 2003; Hall and Higham 2005).

Consideration of the total movement of humans in time and space is important because the extent of space-time compression that has occurred for many people in the developed world has led to fundamental changes in individual mobility and in assumptions about personal mobility in recent years. Travel time budgets have not changed substantially but the ability to travel further at a lower per unit cost within a given time budget has led to a new series of social interactions and patterns of production and consumption (Schafer 2000). For many people leisure mobility is now routine. Advances in transport and communication technology that have been adopted by a substantial, relatively affluent, proportion of the population enable such people to travel long distances to satisfy demands for amenities – what one would usually describe as tourism. Indeed, Hall (2005a) has argued that one interpretation of this perspective is that the study of tourism is intrinsically the study of the mobile consumption patterns of the wealthier members of society.

The means of transport used in international tourism changed fundamentally with the rise of civil aviation in the 1960s. From being an option only for wealthy tourists in the 1960s and 1970s, aviation soon became one of the most popular means of transport in international travel, with growth rates in the order of 5–6 per cent per year from 1970 to 1993, and 7.1–7.8 per cent per year from 1994 to1996. Some 40 per cent of all international tourist arrivals might now be by air (Gössling 2000). At the end of 2002, airlines were actively operating some 10,789 passenger jets with 100 seats or more, representing a total of 1.9 million installed seats.

Boeing (2003) and Airbus (2003) predict that air travel will continue to grow rapidly, with average annual growth rates of 5.0–5.2 per cent to 2022/23. By 2022, the number of aircraft is predicted to increase by 90 per cent to about 20,500, while the number of installed seats will more than double to reach 4.5 million (Airbus 2003). Boeing (2003) also predicts that competition for markets will be strong, leading to more airline entrants, lower fares and improved networks. Simultaneously, it is anticipated that governments will continue to deregulate air travel markets. Consequently, air travel is one of the key factors in international tourism development, outpacing growth in surface-bound means of transport.

Two other aspects of air travel deserve mention in the context of tourism and GEC. First, flight distances are predicted to increase, with the average distance flown growing from 1,437km in 2002 to 1,516km in 2022 (Airbus 2003). Second, a large proportion of the current fleet of aircraft (60 per cent) will still be in operation 20 years from now (Boeing 2003), indicating long operation times for aircraft and concomitant high fuel use for older models still in use. The estimated scale of international tourism growth, as well as the enthusiasm from the tourism industry that seemingly accompanies such growth, is well illustrated in the World Tourism Organization's (WTO) 2020 vision:

> By the year 2020, tourists will have conquered every part of the globe as well as engaging in low orbit space tours, and maybe moon tours. The Tourism 2020 Vision study forecasts that the number of international arrivals worldwide will increase to almost 1.6 billion in 2020. This is 2.5 times the volume recorded in the late 1990s … Although the pace of growth will slow down to a forecast average 4 per cent a year – which signifies a doubling in 18 years, there are no signs at all of an end to the rapid expansion of tourism … Despite the great volumes of tourism forecast for 2020, it is important to recognise that international tourism still has much potential to exploit … the proportion of the world's population engaged in international tourism is calculated at just 3.5 per cent.
>
> (WTO 2001: 9, 10)

Whether such rates of growth are possible is debatable given the potential impacts of future increased fuel prices or 'wildcard' events such as an economic or political crisis, such as occurred in Asia in 1997/98 (Hall 2005a). However, the broader and probably more important debate, as to whether such rates of growth are sustainable or even desirable given the potential environmental effects of such growth, is not really being fully entered into in the academic field and certainly not by leading tourism bodies such as the WTO and the World Travel and Tourism Council (WTTC). For example, the *Blueprint for New Tourism* published by the WTTC in 2003 does not even acknowledge the potential relationships between tourism and global climate and environmental change. The WTO has recently described the interaction of tourism and climate change as a 'two-way relationship' (WTO 2003), but there is no official document, as yet, dealing with this problematic interaction. Quite the contrary, the WTO's STEP programme (WTO 2005) fully ignores the environmental consequences of leisure transport.

Global environmental change

There is comprehensive evidence for GEC caused by human activities: land-use changes, altered biogeochemical cycles, climate change, biotic exchange, as well as disturbance regimes (e.g. tropical storms) have been described in a wide range of publications (Klein Goldewijk 2001, Sala *et al.* 2000, IPCC 2001, Loh and Wackernagel 2004). GEC will have complex consequences for ecosystems, as well as for social and economic systems. Biodiversity will mostly be affected by land-use changes, followed by climate change (increasing temperatures), nitrogen deposition, biotic exchange and atmospheric CO_2 concentration increases (Sala *et al.* 2000). Note, however, that different biomes will be affected to varying degrees by these changes – for example, Arctic environments will mostly suffer from increasing temperatures (ACIA 2004). Global environmental change will also affect human social and economic systems though increasing temperatures, sea-level rise, changing precipitation patterns and weather extremes, which in turn will cause other environmental changes, such as new disease frontiers, coastal erosion and new patterns of urbanization and mobility. We shall now discuss the observed and predicted patterns of some key parameters of GEC.

Temperature increase

Global average surface temperatures, the average of near-surface air temperature over land and sea surface temperature, are changing. As documented by the Intergovernmental Panel of Climate Change (IPCC) – a scientific body created in 1988 by the World Meteorological Organization and the United Nations Environmental Programme – global average surface temperatures have increased by 0.6 ± 0.2°C over the twentieth century (IPCC 2001). Globally, the IPCC anticipates that the 1990s were the warmest decade and 1998 the warmest year since 1861, when temperature measurements were introduced.

There is even more evidence for ongoing climate change. For example, since the late 1950s, when weather balloons were introduced, global temperature increases in the lowest 8km of the atmosphere and in surface temperature have been about 0.2°C per decade. Since 1979, information is completed by satellite records, which show that the global average temperature of the lowest 8km of the atmosphere has changed by 0.05 ± 0.01°C per decade; however, global average surface temperature has increased even more rapidly, by 0.15 ± 0.05°C per decade. Satellite data also shows that the extent of snow cover might have decreased by about 10 per cent since the late 1960s, while ground-based observations show that the annual duration of lake and river ice cover in the mid- and high latitudes of the northern hemisphere might have reduced by two weeks over the twentieth century (IPCC 2001). Other observable changes include the retreat of glaciers all over the world, and there is now evidence that the Western Arctic Ice Shield is melting (Payne *et al.* 2004). For example, between 1980 and 2004 Chinese scientists measured a 5.5 per cent shrinkage by volume in China's 46,298 glaciers, a loss equivalent to more than 3,000km^2 (1,158 square miles) of ice; with there being a noticeable acceleration in recent years. The effects are so dramatic that it is predicted that two-thirds of China's glaciers – which are estimated to account for 15 per cent of the Earth's ice – would disappear by the end of the 2050s, and almost all would have melted by 2100 (Watts 2004).

Overall, there is thus compelling evidence that climate change is real and, furthermore, that it is primarily caused by human emissions of greenhouse gases, mainly as a result of the burning of fossil fuels (IPCC 2001). The warming effect of greenhouse gases is measured in terms of radiative forcing, which in turn can be translated into an increase in global mean temperature. From 1750 to 2000, all anthropogenic emissions of greenhouse gases have caused an additional radiative forcing of 2.43 Wm^{-2}, of which 1.46 Wm^{-2} is from CO_2 – the most important anthropogenic greenhouse gas – 0.48 Wm^{-2} from CH_4, 0.34 Wm^{-2} from the halocarbons and 0.15 Wm^{-2} from N_2O (IPCC 2001). The observed depletion of the stratospheric ozone layer from 1979 to 2000 is estimated to have caused a negative radiative forcing of –0.15 Wm^{-2}. On the other hand, ozone in the troposphere is estimated to have increased, leading to a positive radiative forcing of 0.35 Wm^{-2}. The human dimension of climate change needs to be highlighted because policy makers and the media – particularly in countries such as Australia and the USA which have not signed the Kyoto accord – frequently assert that climate change is highly uncertain. These assertions have been used as an argument against adopting strong measures to reduce greenhouse gas emissions (O'Riordan and Jäger 1996; Sarewitz and Pielke Jr. 2000; Brown and Oliver 2004; Gow 2004a, b).

Generally, climate change is analysed through climate models. Such models cannot be used to make exact statements on the character of future climate change, because there is a range of uncertainties concerning the parameters used, their interaction and feedback processes, as well as future emission levels of greenhouse gases. Clearly, modelling the world's climate is an extremely complicated exercise. Hence, models still need to be improved (von Storch *et al.* 2004) and might for years to come imply a degree of uncertainty. Nevertheless, they are already now deemed to be sufficiently reliable to address the question of how the climate will respond to increasing greenhouse gases.

For example, while there is still controversy over the cause and extent of natural climate variability in the past (Moberg *et al*. 2005, see also Figure 1.2), warming as observed since the mid-1980s is unprecedented and unquestioned in terms of its human cause. Natural fluctuations, if underestimated in current models, are of importance because they might 'either amplify or attenuate anthropogenic climate change significantly' (Moberg *et al*. 2005: 617). In other words: uncertainty increases the risk factor implicit in current models (Challenor *et al*. 2005). In the past, climate models have pointed at temperature increases in the range of 1.4 – 5.8°C by 2100 (IPCC 2001), with a likely scenario of a 3°C warming by 2100 (Kerr 2004: 932; see also Figure 1.2). Recent research indicates, however, that the range might very well be larger, with up to 11.5°C warming by 2100 (Challenor *et al*. 2005; Stainforth *et al*. 2005). Any warming beyond 3–4°C is assumed to have adverse impacts for coastal resources, biodiversity, marine and terrestrial ecosystem productivity and agriculture (Hitz and Smith 2004; Parry 2005).

It is also worth noting that temperature increases are not likely to be linear. A recent example is the summer 2003, which was probably the hottest in Europe since AD1500 (Stott *et al*. 2004), and which is a good example of increasing temperature variability in European summer heatwaves as a result of climate change (Schär *et al*. 2004). The social, environmental, economic and political consequences of the heatwave were complex. Schär and Jendritzky (2004) report that, according to reinsurance estimates, drought conditions caused crop losses worth US$12.3 billion in Europe, plus an additional US$1.6 billion in forest fire damage in Portugal. European electricity markets reacted with increasing energy prices, because power plants had to curtail production owing to the lack of cooling water, with electricity spot prices rising beyond €100 (US$130) per

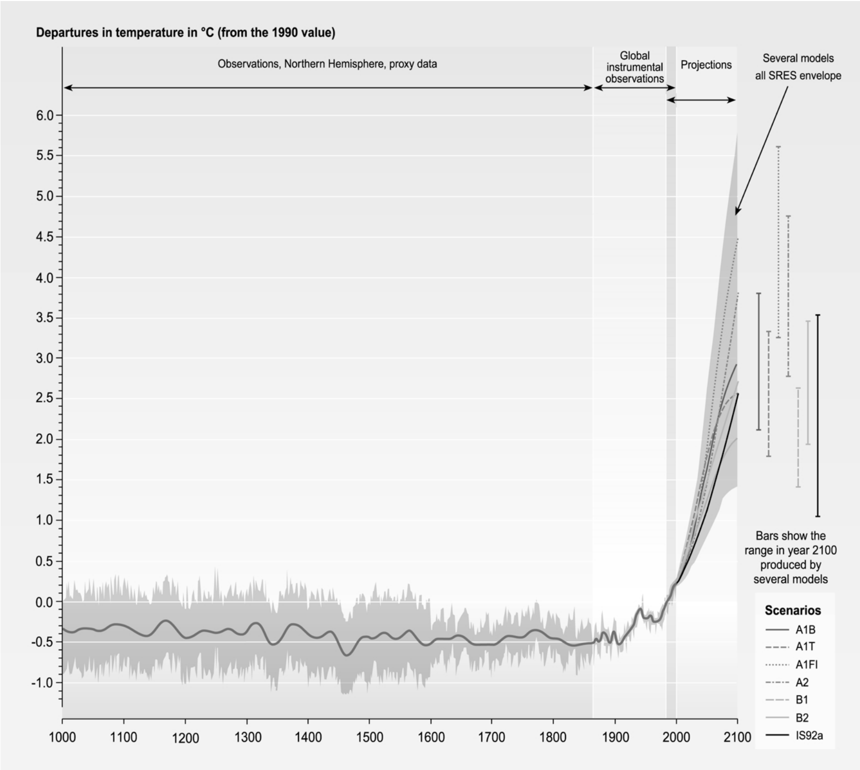

Figure 1.2 Variations in the Earth's surface temperature, 1000–2100

Source: reproduced by permission of IPCC (2005)

MWh. Schär and Jendritzky (2004: 559) continue their list of fatal consequences of the heatwave:

> In the Alps, many glaciers underwent unprecedented melting, and the thawing of permafrost led to a series of severe rock falls. But it was the unusual number of deaths during 1–15 August that caught the headlines. Estimates based on the statistical excess over mean mortality rates amount to between 22,000 and 35,000 heat-related deaths across Europe as a whole. In France the mortality rate increased by 54 per cent during those two weeks, and the increase was statistically significant in all 22 French regions and for all age groups above 45 years.

The consequences of the heatwave even had political dimensions. In France, for example, the government's mishandling of the heatwave – old people were not taken care off because of the country's prolonged summer vacations, causing the death of approximately 15,000 people – was suggested as being part of the reason for the election of the moderate-right government over the socialist party in later elections (Caldwell 2003). Stott *et al*. (2004) analysed whether the heatwave was already a result of human interference with the climate system; this is whether it was caused by human greenhouse gas emissions. They conclude that it is impossible to say whether any such weather event might have occurred by chance in an unmodified climate, but that it is nevertheless possible to estimate 'by how much human activities may have increased the risk of the occurrence of such a heatwave' (Stott *et al*. 2004: 610). At a confidence level of greater than 90 per cent, more than half of the risk of the 2003 heatwave is attributable to anthropogenic changes to the climate system, and summers like the one of 2003 might become the norm by the middle of the twenty-first century.

Sea-level rise

One of the most important consequences of temperature increases will be sea-level rise, a result of the thermal expansion of the oceans as well as the melting glaciers and ice caps. According to the IPCC (2001), the average global sea level has risen by between 0.1 and 0.2m during the twentieth century, and the IPCC's scenarios predict a sea-level rise of 0.09–0.88m by 2100. The current state of the West Arctic Ice Sheet is of great concern because if it melted completely it could raise global sea levels by approximately seven metres (Oppenheimer and Alley 2004). While such a scenario is unlikely (however, see Rapley 2005), there still is potential for a marked increase in the rate of sea-level rise due to accelerated ice loss (Payne *et al.* 2004).

Sea-level rise will have substantial socio-economic consequences, because it will lead to changes in flooding by storm surges, lead to the loss of coastal wetlands and biodiversity (Nicholls 2004), cause land inundation and coastal erosion (Nicholls 2004, Zhang *et al*. 2004). Zhang *et al*. estimate that, given a sea-level rise towards the higher end of the IPCC's 2001 scenarios (i.e. a 90cm sea-level rise), at least 100 million people living within one metre of mean sea level will be affected.They also point out that some of the most heavily developed and economically valuable real estate will be threatened by coastal erosion, which includes many areas of high tourism and recreational significance (Zhang *et al.* 2004). As coastlines are lost, constructions adjacent to such areas will be damaged or destroyed, with the rate of long-term sandy beach erosion being two orders of magnitude greater than the rate of sea-level rise. Human vulnerability will, however, largely depend on economic and political opportunities to invest, for instance, in coastline protection (Nicholls 2004). Nevertheless, in several countries, such as the Netherlands and the United Kingdom, there is now substantial policy pressure to remove coastal protection measures from some areas because the cost of maintaining them is extremely high, while wetlands may be able to be restored in areas that have previously been drained. Nicholls (2004) also demonstrates that the loss of coastal wetlands due to sea-level rise might be in the order 5–20 per cent by the 2080s. Obviously, sea-level rise will have the most severe consequences for low-lying countries, particularly if coupled with other GECs, such as weather extremes. Small Island Developing States have thus been identified as the areas most significantly impacted by sea-level rise: ' … vulnerabilities already exist [in SIDS] that will only be exacerbated by accelerated global warming' (London 2004: 500). For example, 85 per cent of the population, 80 per cent of the infrastructure and 90 per cent of the economic activity of St Vincent are located on a coastal strip less than 5km from the high-water mark and 5m above sea level (SVG 2000, cited in London 2004). Similar is true for a wide range of other islands.

Land-use change

Land use is changing on a global scale (Richards 1990; Klein Goldewijk 2001). A growing world population and changes to diet associated with demands for better living standards mean that increasing amounts of land are being converted from a relatively natural state to agricultural land use. The land area needed to feed people depends on factors such as diet, soil productivity, water availability, and chemical and energy inputs into the agricultural system.

The average area of arable land needed to support the diet of a person from the developed countries is estimated at 0.5ha per person (ha/p) (Giampetro and Pimentel 1994). The average arable land area for a person on a mainly vegetarian diet has been estimated at 0.2ha/p (Engelman *et al*. 2000), although the borderline of arable land scarcity has been estimated at 0.07ha/p (Smil 1993). Nielsen (2005) estimates that the global average available in 2003 was 0.24ha/p and that, based on low-level projections of world population growth, the average available in 2025 will be 0.16ha/p, and 0.11ha/p in 2050. The biologically productive surface area required to support the average consumption of Western Europe has been estimated at 6.0ha/p and for very poor countries at 1.0ha/p. In 2003, the global average available was estimated at 1.8ha/p with a forecast of 0.7ha/p for 2050 (Nielsen 2005; also see Wackernagel *et al*. 2002). Urban areas only occupy between 1 and 2 per cent of all land resources. However, expanding urban areas often directly occupy highly productive agricultural land, while the ecological footprint of urban centres means that they impact an area far wider than the immediate city.

The available land area per person is decreasing not only because of population growth but also because of land degradation and the impacts of climate change (Bugmann 1997; IPCC 2001; Hannah *et al*. 2002; Williams *et al*. 2003; Cox *et al*. 2004; Parry *et al*. 2004; Parry 2005). Causes of land degradation include deforestation, poor agricultural practices, urbanisation and industrialisation, pollution, salination, acidification and waterlogging. It is estimated that, between 1945 and 1990, 1,965 million hectares was lost through soil degradation, a rate of 44 million hectares per year (Nielsen 2005). The rate of degradation of arable land has been estimated at approximately 10 million hectares per year (Nielson 2005). In the case of Western Australia, for example, one of the world's biodiversity 'hotspots', 18 million of the 25 million hectares originally covered by native vegetation has been cleared. Of this, 1.8 million hectares is salt affected to some degree, with 80 per cent of the waterways in the south-west also significantly affected by salt (Water and Rivers Commission 2000). Indeed, on a global scale Parry (2005) noted that some thresholds – with respect to such issues as water stress, global cereal production and flooding – have already been exceeded at a regional level and warned that, at a global level, while there may be some positive impacts for agriculture, terrestrial ecosystem productivity and forestry at low levels of climate change, there will be negative and increasing damages at higher levels of climate change. However, negative biodiversity and dispersion impacts are expected to occur alongside of positive net ecosystem productivity even at low rates of change (Leemans and van Vliet 2005; Parry 2005).

The interrelationship of land-use change with population increase means that ecological capacities are increasingly being stretched, and are exceeded in a number of the developed countries.

> If the combined global footprint is smaller than global ecological capacity, we are still within the limits of sustainability. However, if our combined global footprint is larger, we are living beyond our means – that is, with a global ecological deficit.
>
> (Nielsen 2005: 36–7)

Tourism is a part of the processes of land-use change because of its contribution to consumption and its own ecological footprint (Gössling *et al*. 2002). However, tourism is also affected by land-use change because of the loss of resources, such as biodiversity and amenity landscapes, that serve to attract visitors.

Precipitation patterns

Global precipitation patterns have changed substantially in recent decades, both with respect to amount and intensity. According to the IPCC (2001), precipitation might have increased by 0.5–1 per cent per decade in the twentieth century over most mid- and high latitudes of the northern hemisphere continents, and rainfall by 0.2–0.3 per cent per decade over the tropical land areas (10°N to 10°S). However, increases in rainfall in the tropics are not evident over the past few decades and, in the northern hemisphere sub-tropical land areas (10°N to 30°N), rainfall may have decreased during the twentieth century by about 0.3 per cent per decade. No changes have been observed over the southern hemisphere, and data is insufficient to establish trends over the oceans.

So far as the intensity of precipitation patterns are concerned, there seems to be a 2–4 per cent increase in the frequency of heavy precipitation events in the mid- and high latitudes of the northern hemisphere over the latter half of the twentieth century. Heavy precipitation events can be a result of changes in atmospheric moisture, thunderstorm activity and large-scale storm activity. Precipitation patterns can also be affected by El Niño-Southern Oscillation phenomena (see below, *Extreme climate and weather events*). Globally, runoff is expected to increase by 4 per cent given a 1°C global temperature rise, a result of more intense evaporation above oceans coupled with continental precipitation (Labat *et al*.

2004). Note, however, that there are increasing and decreasing runoff trends on intercontinental and regional scales as indicated above.

In Europe, models predict substantial changes in precipitation patterns (Xu 2000). More intense precipitation, most of which is projected to occur in winter, will contribute to increased lake inflows, lake levels and runoff (see Palmer and Räisänen 2002). During the summer, drier conditions, exacerbated by greater evaporation, will reduce lake inflows and lake levels. Higher temperatures and decreasing water levels in summer may also affect thermal stratification, evaporation and species composition of lakes (Hulme *et al*. 2003). Sweden is one country where changes in precipitation patterns have been investigated quite thoroughly (SWECLIM 2002). Models for Sweden predict increases in precipitation in the order of 30–60 per cent by 2100, which will be unevenly distributed over the year. In winter, precipitation will increase and might fall as rain rather than snow. This, in turn, will cause faster snowmelt (see ACIA 2004). During the summer, rainfall will decrease and lake waterlevels will fall. Over the whole year, rainfall is predicted to be more intense (SWECLIM 2002). For streams, this implies that winter runoff will increase and spring and summer runoff decrease (Xu 2000). Increasing river discharge to the ocean has already been observed over much of the Arctic, with spring peak river flows now occurring earlier (ACIA 2004). In the northern latitudes, melting glaciers might also contribute to greater runoff.

Extreme climate and weather events

Extreme climate and weather events have cost millions of human lives in the past decades, and there is evidence that some extremes have become more frequent. For example, warm episodes of the El Niño-Southern Oscillation phenomenon have been more frequent, persistent and intense since the mid-1970s, compared with the previous 100 years (IPCC 2001). Furthermore, in some regions such as parts of Asia and Africa, the frequency and intensity of droughts have been observed to increase in recent decades. While these patterns seem to be connected to GEC, it should be noted that alterations in tropical and extra-tropical storm intensity and frequency are dominated by inter-decadal to multi-decadal variations, and no significant trends are evident over the twentieth century. Similarly, no systematic changes in the frequency of tornadoes, thunder days, or hail events were observed (IPCC 2001).

Table 1.1 shows that changes in climate and weather phenomena have, with high probability, already occurred in the latter half of the twentieth century and will, with even higher probability, continue in the twenty-first century. For example, higher maximum and minimum temperatures over land areas have been observed in the latter half of the twentieth century and will with high probability continue to be seen in the future. The diurnal temperature range will be reduced, while the heat index will increase. More intense precipitation events are likely over many northern hemisphere mid- and high latitude land areas, and very likely over many areas in the future. Increased summer continental drying and risk of drought is likely to have occurred in some areas in the latter half of the twentieth century, and is likely to occur over most mid-latitude continental interiors in the future. An increase in tropical cyclone peak wind intensities has not been observed in the analyses available as yet; however, such increases are likely over some areas in the future. Finally, there is insufficient data for the assessment of the increase in tropical cyclone mean and peak precipitation intensities, but these are likely over some areas in the future (IPCC 2001).

Weather extremes are costly, as exemplified by well-documented events in the USA. In the period 1980–2004, the USA experienced 62 weather extremes: 53 of these disasters occurred since 1988, and seven events were in 1998 alone. These weather extremes, mostly hurricanes, caused hundreds of deaths, and the total normalised losses from the 62 events are over US$390 billion – including wide-scale, long-lasting events such as drought (NOAA 2005). Another potentially serious impact of extreme weather events is their potential impacts on species and ecosystems (Leemans and Eickhout 2004). Although climate change has an impact on species through such factors as timing of life cycle events and impacts on the structure and dynamics of geographic ranges, it has been recognised that since 1990 there has been greater ecological response than could be expected from the observed average 0.7°C warming trend alone. Observed responses of ecosystems and species correlate better with changes in extreme weather events, such as heat waves, heavier precipitation, fewer cold extremes and high-magnitude storm events, than with 'normal' climate characteristics (Leemans and van Vliet 2005). As a result of such findings, the projected impacts of climate change (e.g. IPCC 2001) on species and ecosystems are likely to be substantially underestimated.

Tourism and environment

The relationship between tourism and the environment has been the object of scientific research for more than 30 years. Figure 1.3 illustrates how 'the environment' made its entry into the field of tourism studies. In the 1950s, when tourism started to grow rapidly in the post-World War II era, it was mainly seen as an economic sector with great potential for national economies, opening up opportunities for recreation and leisure for large parts of the population in the industrialised countries. It was not until the rise of the green movement in the 1960s and 1970s that environmental impacts of tourism were realised. However, these were generally 'local' in character – focusing on erosion problems or beach crowding – and it was not until the publication of Swiss scientist and environmentalist Jost Krippendorf's *Die Landschaftsfresser* (*The landscape devourers*) (1975) that the environmental impacts of tourism were perceived by a broader public in Europe. Although the work of Mathieson and Wall (1982) charts the development of early awareness of the impacts of tourism in specific environments, there has not been a publication – similar to that of Krippendorf – in the English language literature that has encouraged a wider public debate on tourism's environmental impacts. Instead, tourism often remains something that impacts negatively 'somewhere else'.

During the 1960s and 1970s, the evaluation of environmental 'impacts' was usually based on aesthetic judgements and/or questionable scientific methods, and

Table 1.1 Changes in climate and weather phenomena

Changes in phenomenon	*Confidence in observed changes (latter half of the 20th century)*[1]	*Confidence in projected changes (during the 21st century)*[1]
Higher maximum temperatures and more hot days over nearly all land areas	Likely	Very likely
Higher minimum temperatures, fewer cold days and frost days over nearly all land areas	Very likely	Very likely
Reduced diurnal temperature range over most land areas	Very likely	Very likely
Increase of heat index[a] over land areas	Likely, over many areas	Very likely, over most areas
More intense precipitation events	Likely, over many northern hemisphere mid- to high latitude land areas	Very likely, over many areas
Increased summer continental drying and associated risk of drought	Likely, in a few areas	Likely, over most mid-latitude continental interiors (lack of consistent projections in other areas)
Increase in tropical cyclone peak wind intensities	Not observed in the few analyses available	Likely, over some areas
Increase in tropical cyclone mean and peak precipitation intensities	Insufficient data for assessment	Likely, over some areas

Source: IPCC 2001

a Heat index: A combination of temperature and humidity that measures effects on human comfort.

1 The IPCC uses the following expressions to indicate confidence levels: *virtually certain* (greater than 99 per cent chance that a result is true); *very likely* (90–99 per cent chance); *likely* (66–90 per cent chance); *medium likelihood* (33–66 per cent chance); *unlikely* (10–33 per cent chance); *very unlikely* (1–10 per cent chance); *exceptionally unlikely* (less than 1 per cent chance)

often forwarded in rather popular assessments with the aim of being thought-provoking and reaching large parts of the population. Criticism was maintained during the 1980s, its perspective now becoming global (see Mathieson and Wall 1982). Environmental problems were assessed by newly developed methods and solutions presented. For example, Butler (1980) presented his famous destination lifecycle model, suggesting that any destination would inevitably face decline if social, economic or environmental conditions became less favourable (a work that was based on earlier publications that highlighted destination decline, see Wolfe

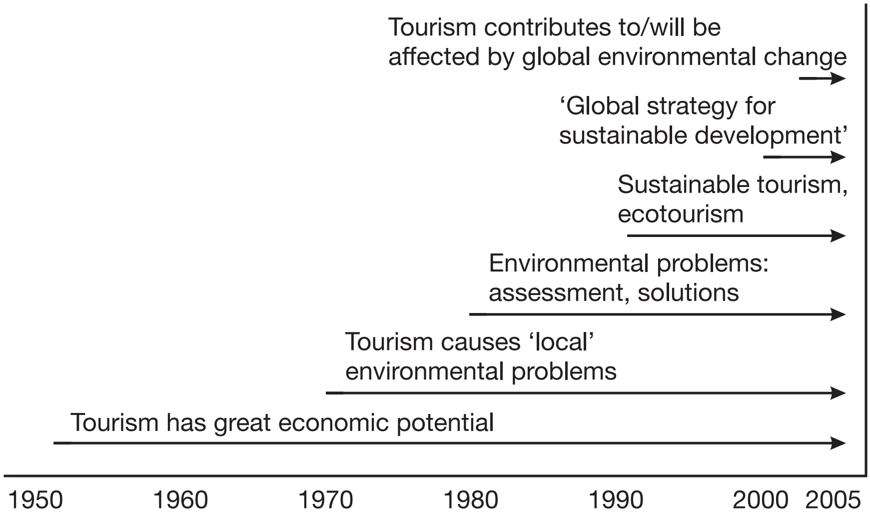

Figure 1.3 Themes in the context of tourism and environmental change

1952; Christaller 1963; Stansfield 1978; Hall 2005b). O'Reilly (1986) emphasised the concept of interrelated environmental, social, economic and perceptional carrying capacities. Since then, a wide range of tools have been developed to assess and cope with environmental change, including the Level of Acceptable Change concept (LAC) and the Environmental Impact Assessment (EIA). These concepts are used frequently, for example, an EIA is a prerequisite for tourist infrastructure development in many countries. Likewise, the carrying capacity concept has been the focal point of recent research (Cocossis and Mexa 2004). However, all these concepts and models remained local in character.

Following the publication of the Brundtland Report in 1987 (WCED 1987), the term sustainable development became widely used in relation to tourism (see Butler 1993). However, the term 'sustainable development' had been used in relation to tourism and the World Conservation Strategy prior to the WCED, and 'sustainable tourism' became a new paradigm in the quest for minimised environmental, social and economic impacts of travel and recreation. The term 'ecotourism' also emerged in the mid-1980s, but was not as yet understood in its current meaning of 'responsible travel to natural areas that conserves the environment and improves the well-being of local people' (International Ecotourism Society 2004; note that a wide range of similar definitions exist). The emergence of sustainable tourism and ecotourism resulted in a shift towards a more positive view of tourism's environmental and economic contributions.

This positive view is expressed on several levels, including an openness to acknowledge the environmental consequences of tourism that were earlier denied or disregarded by the tourist industry and its organisations, but also a more self-confident position that tourism is both sustainable and more beneficial than other industries. For example, the German company TUI, the world's largest tour operator, suggested in 1997 that tourism should become 'a global strategy for sustainable development'. Similar views are mediated by the industry's own organisations such as Green Globe 21, a worldwide certification scheme for 'sustainable' tourism developed by the WTTC.

Scientifically, this is challenged by the insight that the global environmental consequences of tourism have been neglected in past assessments, and that tourism is an important contributor to land-use changes, loss of biodiversity, emission of greenhouse gases, resource depletion, and so on (e.g. Høyer, 2000; Gössling, 2002; Gössling *et al*., 2002; Ceron, 2003; Peeters, 2003; Hall 2005a; Hall and Higham 2005). This insight has recently been acknowledged by the WTO, which notes that tourism and climate change need to be seen as a 'two-way relationship' (WTO 2003), although as noted above the potential implications of climate change or GEC have not been incorporated into forecasts for future tourism growth. For example, the WTTC (2003: 5) blueprint for 'new tourism' states:

> New Tourism looks beyond short-term considerations. It focuses on benefits not only for people who travel, but also for people in the communities they visit, and for their respective natural, social and cultural environments.

However, neither climate change nor GEC is mentioned in the document. The major concern of an increasing number of observers, however, is that tourism is affecting and will be affected by GEC.

Tourism and global environmental change

> Imagine Davos as a long street, which, 150 years ago, was just a country road leading to a village with no more than 30 houses, surrounded by alpine hills, behind which, as a supreme promise to skiers, genuine Swiss rock formations loomed. Here, in this classic Thomas Mann Magic Mountain landscape, where one could cure his tuberculosis or pass away in all decadence, a quite unalpine shoe-box architecture has spread in the past five decades, box next to box – hotels that, when planned, could not as yet be interpreted as memorials of tourism against the undeniable change of the global climate. In other words: the past five years were the hottest since weather statistics have been kept in Europe. Glaciers are melting, snow cannons work in January, the snow cover is thin, and at some point in time all of these hotels will be standing vacant and be admitted to social purposes.
>
> Naumann (2005) [authors' translation]

The importance of environmental assets for tourism is well understood, because a wide range of recreational activities are dependent on climatic and natural resources. Climatic resources include the thermal characteristics of destinations, with warmer climates generally being more attractive for the broad majority of holidaymakers. Coastal zones are the loci of tourism activities throughout the world, followed by mountain environments. The Mediterranean alone sees more than 100 million international tourist arrivals per year, and the European demand for long-haul sun and sea tourism was estimated to be in the order of 10–12 million in 1998 (WTO 2001). On the other hand, low temperatures guarantee lasting snow cover in winter sport resorts. The WTO estimates that there are some 25 million skiers worldwide, plus another 10 million snowboarders, cross-country skiers, etc. (WTO 2001). Other climatic parameters such as rainfall, hours of sunshine and wind speed, as well as their temporal pattern, greatly influence the appeal of particular destinations (for a recent collection of conference papers see Scott and Matzarakis 2004). Natural assets of importance for tourism include essential resources such as fresh water (see Chapter 10, this volume) and food availability, as well as the physical environments attracting tourists, often high-value amenity landscapes (see Chapters 2 through to 7, this volume). Likewise, biodiversity is also of great importance as a tourist attraction at both the ecosystem and species level (see Chapter 12, this volume).

Climatic assets

Tourist preferences vary throughout the world, and it seems difficult to make generalising statements on climatic requirements for tourism. It is widely recognised, however, that tourism is subject to weather and climate, with travel decisions being based to a large extent on images of sun, sand and sea, or the availability of snow, and thus on climate variables such as temperature, rain and humidity (e.g. Smith, 1993; de Freitas, 2001). Because of this, it is expected that climate change will affect travel behaviour, both as a result of altering conditions for holidaymaking at the destination level and climate variables perceived as less or more comfortable by the tourists. In particular, the effects of increasing temperatures and related parameters (such as rain) on the choice of a destination and time of departure have been the focus of recent research. For example, in an attempt to identify 'optimal' temperatures, Maddison (2001) analysed travel patterns of British tourists and found that the maximum daytime temperature perceived as comfortable was 30.7°C, with even small increases above this level leading to decreasing numbers of visits. Maddison also found that greater rainfall would deter tourists. In another study, Lise and Tol (2002) analysed a cross-section of destinations of Organisation of Economic Co-operation and Development (OECD) tourists. Using factor and regression analysis, they found that OECD tourists preferred an average temperature of 21°C at the hottest month of the year at their destinations. Both studies conclude that tourists may shift to other destinations or travel during other periods of the year under a scenario of climate change.

Statistical models express the behaviour of tourists as a function of weather, climate and other factors – such as travel costs – and thus need to be seen as top-down approaches to understanding the interaction of travel choice and climate. Few studies have chosen to analyse tourist perceptions of weather conditions from a bottom-up perspective. Using a combined strategy of climate variable measurements and stated weather perceptions based on structured interviews, Mansfeld *et al*. (2003) assessed the biometeorological comfort of beach tourists in Eilat, Israel. The results show that differences in wind velocity and cloudiness had a significant influence on the tourists' comfort perception which, in this case study with rather moderate temperatures (20–24°C), was negative. Temperature differences also had an influence on the tourists' comfort perception, but the importance of this variable was generally much lower. Mansfeld *et al*. thus suggest that perceptions might be very different under summer conditions, when both wind velocity and cloudiness might be perceived as rather positive. Furthermore, the study revealed that domestic tourists were more sensitive to weather conditions than tourists from overseas, hinting at the importance of other aspects, such as whether the tourists usually live in warm, temperate or cold climates. The study concludes that weather conditions shape the tourists' comfort perception, even though the importance of single variables depends on the background conditions at the destination level – relatively extreme (high or low) weather variables – and the conditions experienced before going on holiday.

Other recent research indicates that the role of weather parameters is not easily understood. For example, Gössling *et al*. (2005a) found that the majority of tourists in an *in situ* case study in Zanzibar, Tanzania, expressed no aversion to a theoretical increase in temperatures, despite high average day temperatures around 30–31°C. The case study confirms that climate is an important aspect of travel decisions, even though many tourists seem to rather implicitly consider 'temperature' in their travel choices. In their *in situ* perception, rain and weather extremes have a far greater effect on travel decisions. Climate variables such as more rain, storms and higher humidity are more likely to negatively influence travel decisions under a scenario of climate change than higher temperatures, which are not necessarily perceived as negative by all tourists. It is acknowledged, however, that the role of weather and climate information in the choice of destinations remains insufficiently investigated, and that the results of this particular case study cannot be extrapolated to the global tourist population (also see chapters in Hall and Higham 2005). Hence, qualitative research indicates a degree of complexity in weather perceptions that is as yet not fully considered in statistical analyses of changing travel patterns under conditions of climate change.

Natural assets

A wide range of publications has sought to assess the consequences of climate change for the natural assets of tourist industries of destinations (e.g. König 1999; Richardson and Loomis 2003; Scott 2003). Most of these publications have warned that tourist destinations might lose part of their attractiveness through climate change, for example, as a result of loss of snow in ski resorts. In some areas, however, there might also be 'gains' in terms of less rain or extended summer seasons. Overall, the impact of GEC on tourism development has still been little explored because the complexity of changing environmental conditions and tourist perceptions is not well understood. In the following section, some of the expected changes are outlined for the environments that are most central to tourism – coastal zones and mountains, as well as biodiversity. More specific and detailed discussions can be found in the following chapters of the book dealing with all environments of importance for tourism.

Coastal zones are the most attractive areas for tourism all around the world. As noted above, the Mediterranean alone receives some 116 million international tourist arrivals per year plus an unknown number of domestic tourist arrivals (WTO 2003). There are also a great number of both cold and warm water islands receiving a growing number of tourists (e.g. Iceland, New Zealand, Caribbean islands, Indian Ocean islands, Pacific islands), who usually account for a substantial share of foreign exchange earnings (Gössling 2003). It is clear that GEC will have severe consequences for coastal environments because it will lead to sea-level rise, coastal erosion, land inundation, flooding by storm surges, and loss of coastal wetlands and biodiversity (Nicholls 2004; Zhang *et al*. 2004). In particular, weather extremes such as El Niño-Southern Oscillation (ENSO) phenomena or tropical storms can result in severe damage. For example, increasing water temperatures, as observed during ENSO phenomena, have been more frequent and intense in recent decades (IPCC 2001). The 1997–98 ENSO, for instance, had a severe impact on the climate of the Indian Ocean. In March and April 1998, seawater temperatures increased by 1.5°C above average values measured during the same period in 1997. Following the event, coral mortality ranged from 50–90 per cent over extensive areas of shallow reefs in the Seychelles (Lindén and Sporrong 1999).

However, while sea-level rise and coastal erosion will have a direct impact on the physical preconditions for leisure, jeopardising leisure opportunities in many areas, it is not clear how tourists will perceive the loss of other resources, such as marine biodiversity. One recent study in Mauritius, for instance, found that snorkelling and diving were important tourist activities with, for example, 62 per cent of the tourists in the sample participating in snorkelling activities. While both snorkellers and divers stated that the abundance of species, unsullied reefs (no broken corals) and good visibility were important criteria for their underwater experience, the results also indicate that only few of the tourists have the knowledge to judge whether environmental conditions in Mauritius are good and reefs healthy. Indeed, there is evidence that environmental conditions are deteriorating (see Gössling *et al*. 2005b). Thus, it remains unclear when environmental conditions reach a state that no longer appeals to tourists. It also raises the question of whether or not tourists are informed about these environmental conditions before going on holiday – that is, whether they are part of the tourists' decision-making process or not.

After coastal zones, mountains are the most important regions for tourism, attracting millions of tourists worldwide. It is clear that mountain ecosystems are among the most vulnerable to GEC, including glacial retreat, melting of permafrost, loss of biodiversity and changing treelines (see Chapter 3, this volume). In particular, increasing temperatures have already had severe consequences for ski tourism in many areas, and will be of even greater importance in the future.

Consequently, the concept of 'snow-reliability' has been introduced, which defines ski-resorts with a 100-day ski season and a minimum 30–50cm snow depth in at least seven out of ten years (Elsasser and Bürki 2002). In some countries such as Norway, high-altitude resorts have already started to advertise snow security. Opportunities to use technical devices such as snow cannons will, in many areas, define whether or not resorts remain economically viable. Scott (Chapter 3, this volume) also reminds us that:

> It is increasingly recognised that the value of the mountain landscape for tourism depends not just on the presence and quality of tourism infrastructure, but also on the quality of the mountain landscape. Consequently, if climate change adversely affects the natural setting (for example, loss of glaciers, reduced biodiversity, fire or disease impacted forest landscape, reduced snow cover) at a destination, the quality of the tourism product could be diminished with implications for visitation and local economies.

Biodiversity can be of great importance for tourism. Bird watchers, for example, might travel around the world to see a particular bird species (Blondel 2002). Salmon is an important species for fishing, along with a wide range of other salt and fresh water species (Svenson *et al*. 2001). Whale watching is now an activity offered in 87 countries in the world (Hoyt and Hvenegaard 2002). Wildlife is generally an attraction, particularly to tourists from industrialised countries where people have fewer experiences with nature. Tourists may often be attracted by environments that differ from those experienced at home, and the exoticism of biodiversity is thus of great importance to tourism, particularly for those destinations that focus on ecotourism and other forms of nature-based tourism that are often connected to national parks and public and private reserves.

Biodiversity can also have an important symbolic function, as exemplified by moose in Sweden, koalas in Australia or the lion in Africa. Without these species, these countries and regions would lose much of their mythical power. However, many species are threatened by GEC. Within a wide range of taxa, such as plants, birds, reptiles and butterflies, it has been estimated that climate change alone will cause 15–37 per cent of species to become committed to extinction by 2050 (Thomas *et al*. 2004). Estimates vary in relation to the climate change scenario and assumptions concerning species' ability to disperse to new habitats if the climate in their old habitat is not suitable anymore (Thomas *et al*. 2004). However, as the chapter on biodiversity illustrates (see Chapter 12), pressures on biodiversity include not just climate change, but also land clearance, changing land use, pollution and tourism urbanisation.

Although much of the focus on biodiversity is on endemic biodiversity, usually in relatively natural ecosystems, it must be noted that agricultural landscapes also provide significant tourism opportunities. Wine and food tourism is a rapidly growing form of special interest tourism that emphasises local foodways. It is regarded as having some potential to maintain heirloom varieties of plants and animals and provide a basis for more sustainable forms of agriculture.

Nevertheless, agricultural landscapes are also subject to the impacts of climate change as well as other processes such as urbanisation. For example, climate change is resulting in stress on some wine regions while improving prospects for others, such as the United Kingdom. Some areas that are cool climate wine regions may trend towards growing warmer region grape varieties by 2100, while some wine styles, such as ice wine, made in Canada, Germany, Austria and Switzerland, will also be threatened by warmer weather conditions. In addition, climate change will mean new pests and diseases to manage, as well as issues with respect to water supply for irrigation (Margolis and Pape 2004). The loss of certain agricultural landscapes because of climate change will undoubtedly have impacts on tourism flows because of the loss of amenity values.

In summary, tourism and recreation are likely to be severely affected by GEC, because both climatic and natural resources will be altered or lost. In particular, it should be noted that tourism usually takes place in areas that are at high risk of being affected by GEC, such as coastal or mountainous zones. It seems clear that low-lying mountain resorts in the temperate zones are facing the most immediate risk of losing their winter tourism potential. Such losses already occur in tourist resorts throughout the Alps and in North America. Potential gains, on the other hand, might occur in summer, even though this remains highly speculative. Similarly, low-lying tropical islands and coastal zones will be at great risk. Even here, this will primarily depend on the extent of extremes. It is also clear that environmental change and vulnerability are interdependent. The tsunami hitting Asia in late 2004, for instance, seems to have hit particularly hard in those regions where environmental change has been most substantial. Even though it was a natural disaster and not a result of GEC, the tsunami seems to have had more severe consequences in areas where coastal zones were more densely populated and where natural ecosystems, such as mangroves and coral reefs, had been damaged, converted or destroyed. Such areas might often be tourist zones, where job opportunities induce coastal zone-directed migration (see Gössling and Schulz 2005) and where natural resources are exploited and/or ecosystems degraded (e.g. Gössling 2001).

Future tourist flows

An increasing number of publications have sought to analyse tourist travel flows in relation to climatic and other parameters such as per capita income. The ultimate goal is to develop scenarios for future travel flows, possibly including ‘most at-risk destinations’. Such scenarios are meant to help the tourist industry in planning future operations, and they are of importance in developing plans for adaptation. While such scenarios are greatly needed, it needs to be acknowledged that the predictability of tourist flows under a scenario of GEC seems difficult (see Table 1.2).

Statistical databases used to predict travel flows are generally insufficient. For example, data provided by the WTO do not distinguish between business and leisure tourists. Instead, statistics refer to ‘international arrivals of tourists by country of residence’, ‘arrivals by nationality’, ‘arrivals in all establishments’ and

Table 1.2 Weaknesses of current models in predicting travel flows

- Statistical database insufficient
- Temperature assumed to be the most important weather parameter
- Importance of other weather parameters largely unknown (rain, storms, humidity, hours of sunshine)
- Role of weather extremes unknown
- Role of information in decision making unclear
- Role of non-climatic parameters unclear (for example, social unrest, political instability, risk perceptions)
- Existence of fuzzy variables problematic (terrorism, war, epidemics)
- Assumed linearity of change in behaviour unrealistic

'arrivals of tourists in hotels'. None of these databases is consistent for all countries in the world. Predicting travel flows on such generalised databases is thus likely to have substantial influence on the reliability of results, because business travellers constitute a large share of international tourists and usually do not travel for reasons related to climate. Business travellers might also influence other correlations, such as the one between a country's poverty line and the number of tourist arrivals, because it seems plausible that there are more business co-operations between wealthier countries, and hence more travel between these. In addition, statistical information is usually at a scale which is insufficient to detail tourist flows between and within regions that would be differently affected by climate change or other dimensions of GEC.

Temperature is often assumed to be the most important weather parameter in the analysis of tourism flows. Outside a certain temperature range, weather perceptions become unfavourable and problems of discomfort arise (McGregor *et al*. 2002). For example, Maddison (2001), in analysing travel patterns of British tourists, found that the maximum daytime temperature perceived as comfortable was 30.7°C, with even small increases above this level leading to decreasing numbers of visits. Based on such analyses, statistical models have sought to predict how travel flows will change in the future with increasing temperatures.

While there is no question that temperature is an extremely important weather parameter with major influence on travel decisions, it should nevertheless be considered that the issue of perceptions is little explored. For example, the expectation of warm destinations might follow a general logic of 'warm is good – warmer is better'. An advertisement campaign by the tour operator Resfeber in Sweden in January/February 2005 portrays well-known cities in the tropics in association with temperatures. The list starts with: 'Bangkok – 32°C', suggesting that temperatures beyond 30°C might not be understood as 'too hot' after all. Perceptions of 'too hot' would also imply that tourists are i) usually informed on the climatic conditions at their holiday destinations and ii) that they are able to interpret this information. While a decent level of information on climatic conditions can only be confirmed for a share of tourists (for the first case study on this issue see Hamilton and Lau, Chapter 13, this volume), it seems questionable whether a tourist is capable of interpreting a 1°C temperature increase in terms of comfort – notably in the absence of information on other parameters such as humidity or wind-speed. Rather, climate in the sense of warm weather conditions at the destination level might often be implicitly considered in travel decisions; there might, for example, be the notion that the tropics are warm. This notion might also be 'broad', in the sense that tourists do not distinguish between 'warm and dry' climates such as, for example, in Tunisia or 'warm and humid' climates such as, for example, in the Indian Ocean islands. This is of importance, because it is generally expected that there is a linear relationship between increasing temperatures and changing travel flows (Lise and Tol 2001, Maddison 2001). Note as well that warming will be more pronounced in the northern latitudes and less pronounced in the tropics, where tourists might expect to find 'hot' climates anyway (see Gössling *et al*. 2005a).

Following this line of reasoning, one might expect *perceptions* to play the most central role in decision making. For example, should the perception of 'warm' countries change toward one of being 'too warm', this might cause rather sudden changes in travel flows on broad regional scales. It is also clear that temperature increase is only linear when measured over long periods, and that there might be great differences from year to year. The fuzzy reaction of tourists to such changes could, for example, be felt in central Europe in summer 2003 (prolonged period of temperatures reaching 42°C peaks) and 2004 (cold and rainy, temperatures generally not exceeding 25°C), when travel decisions were rather random in Germany. Obviously, many people had expected warm summers even in 2004, and made a decision to stay at home. When the weather remained cold and rainy, there was a last-minute rush on charter trips to virtually any 'warm' destination in late July 2004. Newspaper headlines read:

> Hamburg escapes weather-frustration. Last minute record bookings. Stress on airports. Almost all trips booked out.
>
> (*Hamburger Morgenpost*, 14 July 2004)

Weather extremes thus remain the fuzzy variable in the modelling of travel flows. We are warned that:

> … due to the complexity of the Earth-system, it is possible that climate change will evolve differently from the gradually changing scenarios. … For example, storm intensities and tracks could change in unforeseen ways or temperatures could rise or fall abruptly due to unexpected disturbances of global weather systems.
>
> (ACIA 2004: 125)

With more incidences such as experienced during the summers of 2003 and 2004, tourists might become more aware of weather extremes – and either adapt to these or adjust their travel behaviour. Overall, little is known as yet about the complexity of these issues, and it seems unjustified to assume simple relationships.

Outline of chapters

The book is structured in three sections. The first section focuses on the environments of relevance for tourism, followed by a section on factors of particular relevance: water availability, diseases, biodiversity and weather extremes. The final section on adaptation and response opens the floor for discussions by questioning some of the assumed relationships between tourism and GEC. It also contains an overview and an example of adaptation in what can be assumed to be the most vulnerable environments to GEC in the short-term future, mountain environments.

Environments

In Chapter 2, Margaret Johnston outlines threats to polar environments. Northern and southern high latitudes appear to be those that will be most intensively affected by GEC, with average winter temperatures in some parts of the Arctic having increased by 3°C over the past 60 years and Arctic sea ice having diminished by 10 per cent over the past 30 years. Such rapid changes affect landscapes, vegetation patterns and animal behaviour, and thus tourism, which is dependent on scenic landscapes of snow and ice, as well as access to wildlife populations. In particular, climate change might affect options to participate in traditional hunting and fishing, expedition-style and destination cruising, wildlife viewing, northern lights tourism, skiing and snowmobiling, dogsledding, as well as cultural and aboriginal tourism. Hence, Johnston wonders how tourism in the polar regions will change: 'What will it mean for tourists when the inaccessible becomes accessible, and the "inhospitable" climate appears more hospitable?'

In Chapter 3, Daniel Scott examines tourism in one of the most vulnerable environments in terms of GEC. As Scott recognises, this is an environment in which, arguably, some of the most detailed reseach on tourism–GEC relationships have been conducted because of the potential impacts of climate change on alpine and winter tourism.

The importance of lakes, streams, reservoirs, canals and wetlands for a wide variety of leisure activities, including bathing and swimming, recreational boating, sport fishing, ice-skating and bird watching is sketched by Jones, Scott and Gössling in Chapter 4. Global environmental change is likely to affect a number of properties of water bodies, such as water levels, water properties, biodiversity and water supply. Water abstraction, land-use changes, the introduction of alien species and weather extremes may be additional stressors for freshwater systems. Increasing temperatures will also reduce the average number of days that lakes and streams can be used for winter sports activities. Overall, in the case of both mountain environments and water bodies, GEC is likely to have negative effects for recreation and tourism, and many communities depending on tourism might experience substantial economic losses when the resources that attract tourists are scarce, deteriorating and contested.

Boreal, temperate and tropical forest ecosystems are the focus of Chapter 5 by Stefan Gössling and Thomas Hickler. Forest ecosystems are of major importance for recreation and tourism, particularly in Europe, Japan, and other industrialised countries, and attract millions of visitors daily. Forest-based activities include, for example, walking, hiking, mountain biking, cross-country skiing, dog-sledding, fishing, hunting, bird watching, or mushroom and berry collection. Global environmental change will affect forest ecosystems through land-use changes, changing temperatures and precipitation patterns, increasing CO_2 concentrations, and nitrogen deposition. Increasing temperatures, in particular, will have consequences for biodiversity, which is under severe stress through global climate change. Even though these changes will only be felt in the medium-term future, consequences for tourism and recreation might be fundamental.

In Chapter 6, Stephen Craig-Smith, Richard Tapper and Xavier Font focus on the most important natural assets for tourism: coastal zones, islands and reefs. These are the foundations for much of the traditional sun, sand and sea tourism, and these environments also serve as the playgrounds for what the authors call 'post-modern tourists', tourists who are engaged in more active and/or educational activities such as 'surfing, diving, sailing, walking, bird spotting, nature viewing or general exploring'. Clearly, coastlines and low-lying islands in particular will suffer from sea-level rise, rain and cloudiness, storminess and coastal erosion, habitat degeneration and other changes related to GEC, including the potential of increased high magnitude weather events. However, some coasts could also become more attractive to tourism, because they might profit from increasing temperatures.

Robert Preston-Whyte, Shirley Brooks and William Ellery present a GEC scenario for tourism in deserts and savannah regions in Chapter 7. Arid landscapes are fragile and their 'extreme' nature is one of the factors attracting tourists. However, climate change will affect desert environments as there is a trend towards warmer conditions, which will increase evapotranspiration rates in arid areas and lead to a decrease in potential water availability. Together with other pressures, this might substantially change desert and savannah environments and affect in particular those elements that are currently of importance for tourism. For example, eutrophic or arid savannah in South Africa may spread at the expense of dystrophic or moist savannah. It is the latter, however, that is of importance for tourism, because these environments favour a high diversity of spectacular plants and large mammals.

Chapter 8 by C. Michael Hall focuses on tourism urbanisation processes and their relationship to GEC. Hall notes that although urbanisation is a major process in land-use change at the global level, tourism is only responsible for a very small amount of total urbanisation. Nevertheless, the spatial concentration of tourism urbanisation in specific environments, especially coastal areas, means that it still exerts substantial influence on biodiversity in those areas.

Global issues

As outlined in Chapter 4, water bodies are of great amenity value for tourism. Chapter 10 by Gössling focuses on the importance of fresh water for tourism, which is of essential importance for the maintenance of swimming pools, irrigated gardens and bathrooms. Visitors in areas with limited water resources are substantial contributors to water scarcity. Usually, tourism is concentrated in regions such as islands and coastal zones with few fossil water resources, low aquifer renewal rates and few surface water sources. Tourism also causes a shift in global water consumption from regions of relative water abundance to those that are water scarce. Related to these aspects, water quality may often decrease through tourism, as a result of the discharge of untreated sewage, nutrient loads and toxic substances into adjacent water bodies. In many areas, water for tourism has already become scarce, and might even become scarcer through changing precipitation patterns under a scenario of GEC. This may, in many areas, demand technological solutions to cope with the problem – these are usually energy intense and thus accelerate climate change.

In Chapter 9 Hall charts the role of mobility in the spread of disease and argues that the present period of contemporary globalisation presents substantial new challenges with respect to emergent disease control that tourism mobility is exacerbating.

Extreme weather events may be one of the most central aspects of tourism in the future. In Chapter 11, Chris de Freitas investigates whether extreme weather conditions will become more frequent and intense in the future, including hurricanes and other storms, heatwaves, cold waves and high temperatures. Obviously, intense storms are the most severe form of extreme weather conditions and pose a threat to tourists and tourist infrastructure. This is of essential importance in the tropics, where tourism is often concentrated in coastal areas that are at times hit by hurricanes. However, de Freitas argues that there is no clear evidence from climate modelling whether the frequency and intensity of storms will increase in the future.

Chapter 12 by Hall examines tourism's role in conserving biodiversity. Hall notes that tourism is often portrayed as an environmentally friendly industry because of nature-based tourism activities. Yet Hall argues that such an image does not sit easily with the realities of tourism's net contribution to biodiversity maintenance and he argues that species ranges and ecosystem dynamics have been only poorly integrated into wider thinking about ecotourism and its relationship to biological conservation through the establishment of national parks and conservation reserves.

Stakeholder adaptation and perceptions

In Chapter 13 Jacqueline Hamilton and Maren Lau investigate the role of climate information in destination choice decision making, noting that there are a wide range of information sources that people use, as well as a range of values that people use to assess destinations. Shifts in perceptions of climate are also significant for tourism destinations and this issue is taken up in Chapter 14 by Szilvia Gyimóthy who discusses the development of new marketing perspectives in high latitudes.

As Scott points out in the introduction to Chapter 15, even if international agreements to limit emissions of greenhouses gases are successfully established, some climate change is inevitable. Realising this, options and opportunities for adaptation become significant in tourism planning and management. Focusing on the ski industry in North America, Scott presents three general categories of adaptation options: i) hard technological developments (for example, snowmaking); ii) soft business practices (for example, market diversification); and iii) government and industry policy (for example, environmental regulatory frameworks). However, not all ski areas will be able to adapt strategies to cope with GEC because climate conditions will simply become too unfavourable to continue operations.

Issues of adaption in alpine locations are also taken up by Christian Nöthiger, Rolf Bürki and Hans Elsasser (Chapter 16) who discuss the importance of integrating costs of natural disasters into tourism planning based on the example of the avalanches winter 1999 and the storm Lothar in the Swiss Alps. These incidences had substantial costs for the tourist industry and are an inherent danger for any resort operation.

Finally in this section, Erika Andersson Cederholm and Johan Hultman (Chapter 17) present a sociological perspective on tourism and GEC that provides a useful counterpoint to many of the other chapters in the book. They argue that tourism has changed in that it is increasingly built on the marketing of experiences. Experiences, however, are placeless because destinations and their authenticity are social constructions created through TV, websites, catalogues and brochures. Hence, the impact of GEC might primarily be an issue of the geographical reorganisation of experiences, and thus ultimately no more than a spatial redistribution of tourists. Andersson Cederholm and Hultman conclude: 'as long as nature is constructed as an exclusive experiential product, the consumption of nature will have the same communicative function as before even if anthropogenic climate change rearranges nature on a global scale.'

The conclusion by Gössling and Hall argues that GEC presents a major challenge to the tourism industry, not only in terms of adapting to change, but also in finding ways and means by which the impacts of tourism can be mediated. Furthermore, they argue that the tourism–GEC relationship provides significant challenges to the study of tourism that need to be addressed if the global embedding of tourism in systems of production and consumption are to be adequately understood.

For too long the focus of tourism research has been on the destination. However, there is little doubt that anthropogenic environmental change presents a significant challenge to tourism and tourism studies on a global scale. Whether or not the field of tourism studies as well as the tourism industry is able to effectively respond to the practical, intellectual and policy implications of GEC is highly debatable. However, we hope that this book will at least contribute to such a debate, if not to a more profound awareness of the need to respond to the fundamental necessity of conserving our natural capital.

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Part I
Environments and Environmental Change

2

Polar Regions and Tourism: Effects of Global Environmental Change

Margaret E. Johnston

Local effects of global environmental change have been evidenced in both the Arctic and the Antarctic, causing changes, for example, in snow and ice conditions, in vegetation patterns and in animal behaviour. These effects are coincident with changes in opportunities for human activity by local people and visitors. Given that tourism in the polar regions has been largely dependent on scenic landscape attractions, such as snow and ice and access to wildlife populations, there is the potential for major change in this industry. This chapter describes predicted impacts of climate change in these regions and those that are already occurring. It outlines current patterns in polar tourism and identifies several challenges to the tourism industry related to infrastructure, access and attractions. The chapter describes opportunities and challenges created by the local effects of global environmental change and it concludes with the significance of such changes for tourism in the polar regions.

Climate change in the polar regions

On 9 November 2004, the Arctic Climate Impact Assessment was released by the Arctic Council (Friesen 2004), an eight-nation intergovernmental forum that addresses issues in the Arctic. The report predicts major changes to the Arctic resulting from climate change, including decreased sea ice, warmer and shorter winters, thawing permafrost and changes in wildlife populations. The 1400-page report brings together the work of more than 250 scientists (Sallot 2004). The scientist heading the study reported that the average winter temperature in some parts of the Arctic had increased by 3°C over the past 60 years and that Arctic sea ice had diminished by 10 per cent over the past 30 years (Sallot 2004). These changes, evidenced in satellite images and scientific data, demonstrate the vulnerability of the Arctic to climate change and the resulting environmental changes that occur on a variety of scales. Undoubtedly, these environmental changes will influence human activities in global, regional and local contexts. This chapter addresses the issues of environmental change in both the Arctic and the Antarctic and explores the implications of climate change for tourism.

The human dimensions of global environmental change include a focus on how people influence such transformations, the results of those transformations on people, and their adaptations to change (National Research Council 1999). The institutional environment of humans, their economic, political and social contexts, is considered in this perspective, as are the policy implications. The effects of climate change on individuals, communities and societies depend not only on the climatic events themselves, but also on human vulnerability to change and the capacity of people to adapt (National Research Council 1999). It is important to note that on-the-ground impacts and human vulnerability occur on scales very different to those used in climate models. Community and individual responses will reflect local conditions, including endogenous community-level aspects of culture, economy, history and experience with change (Duerden 2004).

Understanding vulnerability and the capacity to adapt are two facets of climate change impact assessments that are derived from the social science literature on risk and hazard. This recent emphasis on vulnerability and the use of integrated regional assessments to focus on the interplay of all direct and indirect impacts along with the adaptations of people and wildlife are advances in how we understand the impacts of climate change. Vulnerability describes the risk a community and individuals face from change, while adaptability refers to their access to economic resources, the capability of public infrastructure to mitigate impacts, and the availability of institutions to manage both sudden onset events and longer term changes. The vulnerability and adaptability of Arctic peoples to sudden and ongoing local changes related to global environmental change has become an important topic for researchers, community members and governments (Berman *et al*. 2004, Ford and Smit 2004), and this work recognises that people are not passive or predictable in their responses (Duerden 2004).

The polar regions are significant in global environmental change because they both are affected by climate change and influence global climate change. Climate change is expected to be greater in the polar regions, with the Arctic particularly affected: more rapid warming is predicted for the Arctic than any other region (International Arctic Science Committee 1994). The Government of Canada reported that analysis of Canadian temperatures from 1895 to 1991 confirmed a similar trend to the global data, but with warming at a higher rate, consistent with the predictions of climate change models for greater warming in high latitudes (Government of Canada 1994). This polar amplification of change is the most important of the three generalisations about climate change. The other two generalisations are that warming will be greater over the land than the sea, and warming will be greater in the winter than in the summer (see Government of Canada 1997).

Models of global warming show temperature increases in the Arctic and some also show increases in some parts of the Antarctic (Wadhams 1991). Further, the Arctic is a critical influence on changes in global climate patterns due to its role in global air circulation and ocean circulation, and in acting as a sink or source of trace gases (International Arctic Science Committee 1994). The Southern Ocean exercises a cooling influence on the world's oceans and may play a role in the stability of the Antarctic ice sheet (Gordon 1991).

Considerable concern has been raised about the contribution of the melting of polar land glaciers to sea-level rises internationally. In Greenland, an increase in temperature is predicted to cause a retreat of the ice margin and, hence, a substantial contribution to sea-level rise as glacial ablation exceeds accumulation (Letréguilly *et al*. 1991). The influence of glacial melting in the Antarctic differs, at least in the shorter term. Research demonstrates that the current expansion of the ice sheet means it is difficult to attribute sea-level rises to melting of the Antarctic ice sheet. Iceberg fluxes reflect disturbance at the front of the ice shelves (Bentley and Giovinetto 1991), and since the weight of floating ice shelves already is accounted for in sea-level, bergs that break off do not contribute to any rise. Indeed, for the next 100 years, the greatest impact of change in the mass balance is predicted to be sea-level lowering because of increased precipitation over the land ice, an offset to the expected rise from temperate glacier melting (Budd and Simmonds 1991). After about 100 years, the effects of increased ice flow from the continent and ice shelf melting would be felt as sea-level rise.

The ice-albedo feedback mechanism is the physical process that appears to be the most important in understanding why the Arctic is expected to warm to a greater extent than the rest of the planet. Fresh snow has a high albedo – high reflection of incoming short-wave solar radiation. When snow cover melts into pools of water, albedo is lowered and thus more radiation is absorbed, causing more melting. This feedback effect will be experienced both for sea ice and land snow cover (International Arctic Science Committee 1994, see also Morison *et al*. 2000). In the Antarctic this effect will be less important because the land is permanently covered with extremely thick ice, and the lowering of the ice-albedo and the resultant feedback effect will only occur with the sea ice, where it will result in retreat and thinning. In the Antarctic, at least 80 per cent of the sea ice in winter is thin, first-year ice, suggesting that this ice will be unstable with warming; however, the complexity of feedback mechanisms related to open water, salinity and depth of warmer water suggest that this thin ice might be resilient (Wadhams 1991). Further, warming in the Peninsula area and cooling in the continent has been confirmed by temperature records from 1966 to 2000 (Doran *et al*. 2002). The Antarctic Peninsula appears to be warming more rapidly than the sub-Antarctic islands and other Antarctic sites, coinciding with a reduction in sea ice extent in the Bellingshausen and Amundsen seas (Jacobs and Comiso 1997; Kiernan and McConnell 2002).

Marine and land ecosystems will be greatly affected by global climate change; indeed, the greatest change is predicted to occur in the high latitudes. These ecosystems are characterised by low species diversity and high adaptation, leaving them vulnerable to environmental change (International Arctic Science Committee 1994). Warming in the Antarctic Peninsula and the sub-Antarctic islands will lead to changes in species, while summer cooling evident in the continent suggests that biologic declines will result (see Doran *et al*. 2002).

Pan-Arctic climate change assessment

The Arctic Climate Impact Assessment (ACIA) is based on scientific observations, indigenous and local knowledge, and the use of scenarios. It describes impacts that are expected to occur in this century and, for each, provides a degree of likelihood that the stated impact will occur, reflecting the level of confidence of the experts (ACIA 2004). The report is organised around ten key interrelated findings. These findings reinforce and extend much of the earlier scientific work on Arctic climate change. These themes are:

1 Arctic climate is now warming rapidly and much larger changes are projected.
2 Arctic warming and its consequences have worldwide implications.
3 Arctic vegetation zones are very likely to shift, causing wide-ranging impacts.
4 Animal species' diversity, ranges and distribution will change.
5 Many coastal communities and facilities face increasing exposure to storms.
6 Reduced sea ice is very likely to increase marine transport and access to resources.
7 Thawing ground will disrupt transportation, buildings and other infrastructure.
8 Indigenous communities are facing major economic and cultural impacts.
9 Elevated ultraviolet radiation levels will affect people, plants, and animals.
10 Multiple influences interact to cause impacts to people and ecosystems.

(ACIA 2004: 10–11)

The report also provides a sub-regional overview that recognises that change is not uniform across the Arctic and that some impacts are more important for some areas than others. For example, in the sub-region from East Greenland to the Scandinavian Arctic and north-west Russia, sea ice retreats will increase access to hydrocarbons and minerals, traditional animal harvests will be less predictable and distributions of plants and animals will shift northward. In the Siberian sub-region, tundra will retreat northward and permafrost will continue to thaw, resulting in infrastructure damage in addition to that already experienced. Increased opportunities for navigation through the Northern Sea Route will bring economic activity and access to oil and gas.

The need to assess these sub-regional effects of global environmental change has become increasingly evident in the polar regions with the recognition of strong regional variation. For example, in Canada, models show greater warming in the interior, greater winter warming, northward movement of the permafrost boundary, and glacier retreat that is more pronounced in the west (Government of Canada 1997). Temperature data confirm this: the western Canadian Arctic has warmed by about 1.5°C over the past 40 years, while the central Canadian Arctic has warmed by 0.5°C over that period (Government of Canada 2001). Precipitation is also regionally differentiated. For example, in Alaska, winter temperature and precipitation variability over a 30-year time period show a warmer, drier climate shift in the interior and a warmer, wetter climate shift along the southern coast (Milkovich 1991).

Yet, not all areas are warming: Hudson Bay is in a transition zone, between annual warming in north-western Canada and cooling in the Baffin Island region (Cohen *et al*. 1994). In the Nordic Arctic, there have been substantial variations in parts of the region over the past century based on data analysis of 20 climate stations in Greenland, Iceland, the Faeroe Islands and Arctic Norway (Førland *et al*. 2002). Increasing temperatures in recent decades might suggest general warming, but these more recent temperatures are still not as high as those experienced in the 1930s and 1950s in parts of the Nordic Arctic. Site differences will also play a role within regions: permafrost thaw is expected to occur more rapidly in the coastal areas and less rapidly in the wetland areas of the Mackenzie Basin (Cohen 1996). The variation between regions continues to be an ongoing challenge for research in this area. A key issue for coming years is making the assessments and predictions of climate change relevant at the regional (and sub-regional) scale (National Research Council 1999).

The ACIA (2004) predictions reflect not only expectations of what will occur, but also changes that are occurring in the physical and biologic world of the Arctic that are now having impacts on people and their activities. Although very little of the literature on the impacts of climate change on human activities delves deeply into effects on tourism, the link to tourism is not a difficult one. All of these changes are linked and all have implications for human activity. This section will explore further several of these changes that have the greatest relevance for tourism.

Changes in sea ice are seen by scientists as a key indicator of the rapid warming of the Arctic (ACIA 2004). A significant decline in the annual extent and thickness of sea ice is evident over the past 50 years, with an acceleration of this decline apparent in recent decades. The extent of sea ice in summer has seen a disproportionate decrease compared to the annual average decrease. The average loss of sea ice in the climate models used by ACIA projected a greater than 50 per cent decline by the end of the century and some models predicted a complete disappearance of summer sea ice.

The scenarios project average annual temperature increases in the latter part of this century to be 3–5°C over land and 7°C over the seas (ACIA 2004). Winter temperature increases will be disproportionately higher: 4–7°C over land and 7–10°C over seas. Increased evaporation with warmer temperatures will lead to increased precipitation for the Arctic as a whole in the order of 20 per cent. Summer rainfall in Scandinavia is expected to decrease and winter precipitation in all areas except southern Greenland is expected to increase. Coastal regions will be most affected by increased precipitation, especially in autumn and winter. The extent of snow cover has already decreased by 10 per cent and it is projected to decrease by another 10–20 per cent by the end of the century, with greatest declines in spring snow cover.

Change in the population and distribution of animal species is another key change expected and evident to some degree in the Arctic (ACIA 2004). Given the major changes to sea ice and the ocean environment, concomitant changes are projected for marine life. Marine mammals are susceptible to changes in climate, as evidenced for numerous species by the effects of El Niño warming in the northern Pacific Ocean, although some, such as the polar bear, might be adaptable to changes in temperature and diet. However, decline in prey populations as a result of sea ice changes and decreased productivity at the ice edge is a threat to polar bears (Ono 1995). Reports from Inuit and scientists also suggest that polar bear territory is being increasingly invaded by grizzly bears, along with other unusual species such as marten, wolverine, robin and Pacific salmon (Struzik 2003).

ACIA (2004) predicts devastating implications for polar bear populations. The health and survival of females and cubs is dependent on success in seal hunting, which requires good spring ice conditions when the bears emerge from their hibernation dens. Polar bears hunt for seals on the sea ice throughout the spring and summer. As sea ice extent and stability continue to decline with warming, individual polar bears and populations will be affected.

> Polar bears are unlikely to survive as a species if there is an almost complete loss of summer sea-ice cover, which is projected to occur before the end of this century by some climate models.
>
> (ACIA 2004: 58)

Impacts on polar bear population health – declines in numbers of adult bears, live births and cub weight – have been documented for the Hudson Bay area, the southern limit of the population. Stirling *et al*. (1999) state that these health declines in the Western Hudson Bay polar bears do not yet threaten this population but that, if trends continue, there will be a detrimental impact on population sustainability.

Some ice-dependent species, such as the ringed seal, spotted seal, harp seal, ivory gull and walrus, will be negatively affected by the decline in sea ice and perhaps will be unable to adapt. Other species, such as the harbour seal and grey seal, might extend their distribution with the reduction in sea ice. Research in the Beaufort Sea indicates that warming and the associated decline in sea ice have already affected the productivity of the ice algae at the base of the marine food chain (ACIA 2004).

Land animals will also be affected, for example as hydrological changes force new migration patterns, flash floods claim lives, and predator–prey relationships are altered through changes in population distribution (ACIA 2004). For example, ‘Despite uncertainty about future ecological relationships, the most likely outcome of a warmer climate will be a decline in caribou and musk-oxen’ (Gunn 1995). Given an increase in weather fluctuations, there will be less winter forage, changes in migration patterns, energy effects of deep, slushy snow, and increased insect harassment, and these will have a negative effect on caribou and musk-oxen.

Flora and fauna changes have been confirmed in the Antarctic as well. Two scientists reported on the ecological impacts of global warming on sub-Antarctic Heard Island (Pockley 2001). Glaciers on the island have retreated by 12 per cent since 1947 and the sea surface temperature has increased. Changes include the development of lush vegetation, the expansion of bird, seal and insect populations. King penguins were reported to have increased from three breeding pairs in 1947 to 25,000 50 years later, and fur seal numbers to have increased from near extinction to 28,000 adults. According to the British Antarctic Survey, grass has become established in the Antarctic – a direct effect of a warming climate (*The Globe and Mail* 2004).

The decline in Arctic sea ice extent is also causing increased wind-generated wave action and more intense storm surges along the Arctic coastline, resulting in severe erosion that threatens numerous low lying Arctic communities (ACIA 2004). Along with increased air and water temperatures, this continuing shoreline erosion is projected to destabilise permafrost, thereby causing increased thawing of the permafrost and further erosion. The effects of these intensified storm surges have been observed in small communities in Alaska (USA) and the Northwest Territories (Canada), where buildings have been abandoned, and transportation infrastructure and continued habitation are at risk.

Even small increases in temperature have an impact on permafrost, the partially or completely frozen ground that lies beneath an active layer of soil or the sea bed in the Arctic. The active layer freezes in the winter, but thaws every summer. When some of this layer fails to re-freeze, the permafrost degrades – the result can be settling of the soil causing damage to overlying structures. Permafrost degradation has already begun across the region and is projected to occur over 10–20 per cent of the current permafrost extent, including a northward shift in the southern limit of permafrost by as much as several hundred kilometres (ACIA 2004). The thawing of permafrost has caused damage to buildings and transportation infrastructure; such problems are increasingly common in northern Russia, largely due to engineering inadequacies and maintenance failures.

Tourism is only one of many interactions that people have with the environment. As such, it will be affected by how much climate change and related environmental changes affect local and regional resource use, and also by unrelated stresses on the system (Table 2.1). For example, with warming in the Mackenzie Basin, deciduous trees are expected to fare better than coniferous trees, as are younger trees compared to older trees (Rothman and Hebert 1997). This will have an influence on forest fires and forest productivity. Yet, at the current time, the forest sector and forestry-dependent communities internationally are being tested by a variety of other forces including technological change and globalisation. Climate change is an additional force that is experienced within this context.

Patterns in polar tourism

A number of sources describe tourism development and issues in the Arctic and Antarctic, including both site-specific studies and more general examinations (e.g. Cessford and Dingwall 1994; Hall and Johnston 1995; Jacobsen 1994; Johnston and Viken 1997; Jones 1998; Notzke 1999; Kaltenborn 2000; Tracey 2000; Bauer 2001). Rather than repeat the detail that these sources can provide, this section outlines some general aspects of polar tourism and relates the impacts of climate change to these. It is important to reiterate that on-the-ground impacts will be experienced very specifically and this current work cannot do justice to that scale of impact.

Tourism in the Antarctic has increased dramatically in recent years although, in comparison to almost all other destinations, numbers remain low. Statistics available on the website of the International Association of Antarctic Tour Operators

Table 2.1 Some aspects of global environmental change with relevance for Arctic tourism

Effects on infrastructure

- Increased open water leads to increased storm surges and shoreline erosion
- Permafrost melting/land instability leads to construction and engineering problems and structural damage

Effects on access

- Decline in sea-ice extent leads to extended shipping season
- Glacier melting leads to increased iceberg hazards
- Shorter seasonal river ice duration leads to access difficulties related to winter roads
- Earlier and greater spring floods leads to access hazards
- Greater snow accumulation leads to access difficulties
- Northward movement of permafrost line leads to increased access through road construction

Effects on attractions

- Greater snow accumulation leads to new opportunities for snow-based activities
- Shorter snow duration leads to seasonal challenges for some activities
- Warmer summer and winter temperatures lead to extension of seasonal activities
- Warmer summer temperatures lead to increased insect challenge
- Warmer winter temperatures lead to new opportunities
- Ecosystem changes lead to alterations in distribution and abundance of existing animal species
- Ecosystem changes lead to appearance of new species in north
- Environmental changes alter local activity possibilities
- Scenic values altered through environmental changes locally and regionally

(IAATO), an industry coalition, show that the number of visitors who made landings doubled from the1992/93 season – when there were 6,704 estimated ship and land-based tourists – to 2002/03 – when there were 13,571 tourists. By 2003/04 the number had tripled to nearly 20,000. An additional 1,500 are predicted by IAATO for 2004/05 (IAATO 2004). These numbers refer to visitors who actually physically visited the Antarctic by ship or by air with a landing on the islands along the Peninsula or the continent itself. Cruises without a landing in 2003/04 contributed another 4,939 tourists, while overflight tourism added 2,827.

Most of the tourism in the Antarctic is ship-based expedition cruising. The 2003/04 statistics show about 400 individuals who travelled by air and participated in activities on land, and 185 tourists who arrived via small sailing vessels (IAATO 2004). Attractions in the Antarctic include wildlife (e.g. penguins, seals), scenic landscape, cultural sites and scientific bases (Tracey 2000). The season is limited to about five-months: mid-November to the end of March, and is concentrated along the western side of the Antarctic Peninsula, an area with a concentration of accessible attractions. Landings by small rubber inflatable craft occur at a variety of popular sites that provide suitable access, as well as diversity and reliability of attractions. Based on the IAATO statistics, the top five most-visited sites from 1989 to 2001 appear to be Whalers Bay, Port Lockroy, Half Moon Island, Cuverville Island and Peterman Island, particularly in the most recent seasons. These island sites in the Peninsula region have visits that number in the thousands. At Whalers Bay in 2003/04 there were 9,941 tourists and at Cuverville Island there were 9,901 (IAATO 2004). In comparison, visits on the continent number at most in the hundreds. Tracey (2000) reports that only a small proportion of sites receive high visitor numbers each year; the vast majority are not used on a regular basis and there continues to be extension of available sites through new site use each year.

Accessibility requires ice-free landings and a reasonably shallow beach or rock entrance to enable boats to approach shore safely and allow visitors to step ashore. There are no docking facilities or jetties at these sites in the Antarctic. It is commonly suggested that this ice-free land is about 1 per cent of the total land mass in the Antarctic. Not coincidentally, there is tremendous pressure on the use of this space; tourism competes at many sites with penguin rookeries, flora and seal haul-outs. As these sites become free of seasonal snow in the spring, they are colonised by successive waves of species.

Helicopters are used regularly for landings, more frequently outside the Peninsula region. The Ross Sea and East Antarctica receive much less visitation than the Peninsula; helicopter use extends the options available and has included, in some cases, access to inland regions such as the Dry Valleys (Tracey 2000).

A small number of tourists each year arrive by air. These visitors are the true adventure tourists in the Antarctic – their access is provided by small planes such as Hercules or Twin Otters to blue-ice runways where seasonal or temporary camps are established as support (Tracey 2000). Activities include climbing, cross-country skiing, wildlife viewing and South Pole visits.

In the Arctic there is a greater range and extent of tourist activity, including traditional hunting and fishing, expedition-style and destination cruising, wildlife viewing, northern lights tourism, skiing and snow-machine riding, dog-sledding, and cultural and aboriginal tourism (see Johnston 1995; Jones 1998; Viken and Jorgenson 1998; Notzke 1999; Tracey 2000; Timothy and Olsen 2001). There is a much longer tourism history in the Arctic, with northern mainland Norway and Svalbard featuring centrally in early Arctic travel (Jacobsen 1994; Viken and Jorgenson 1998). In addition to ship travel, there is considerable air travel and road travel – the latter is more prevalent in the European Arctic where good access leads to destinations such as North Cape. In the North American and eastern Russian Arctic roads are sparse.

For a variety of reasons, accurate numbers of tourists are hard to provide for the Arctic, although estimations can be made using several sources. For example, it is estimated that approximately 33,000 leisure travellers visited the Northwest Territories, Canada, in 1999/2000 (Government of Northwest Territories 2003). Yukon Territory received about 32,000 tourists in 2002 and Alaska had nearly 1.5 million pleasure travellers in 2001 (Pagnan 2003). For all three jurisdictions, it must be noted that there has been no attempt made to separate the Arctic visitors from those who travel to the sub-Arctic. This is a logistical difficulty in much of the north and prevents a clear picture of truly Arctic tourism. Very little Russian data exist, although ship tourism to the Murmansk, the White Sea, Archangel and the North Pole is on offer. The Kamchatka Peninsula is another developing destination region (Pagnan 2003). Nunavut, an Arctic territory in Canada, reported 12,000 visitors and Greenland reported 32,000 (Pagnan 2003).

Iceland (277,800), Finland (1.6 million), Sweden and mainland Norway maintain tourism numbers that are substantially higher. Svalbard, the Arctic archipelago off the northern coast of Norway, has had a rapidly growing tourism industry since the early 1990s when Norwegian authorities began to de-emphasise coal production and promote leisure travel (Viken and Jorgenson 1998). It is reported that ship-based travellers number around 40,000 and that an additional 10,000 tourists arrive by air (Pagnan 2003).

Certain sites have attained international renown for tourism and these draw large numbers of visitors. North Cape, Norway, is one of these, where road access has enabled hundreds of thousands of tourists to access ‘the end of the world’ (Jacobsen 1994). Another well-known site is Churchill, Manitoba, often called the polar bear viewing capital of the world due to the reliable congregations of polar bears in the vicinity. Churchill, at the boundary of the Arctic and sub-Arctic and on the shore of Hudson Bay, boasts a unique combination of physical features, biological attractions and facilities that contribute to hunting, fishing, bird watching, whale watching, northern lights tourism and, of course, polar bear viewing (Lemelin 2005). It is this latter activity that provides Churchill with its international tourism reputation. Polar bears congregate at Churchill in late autumn to await the formation of sea ice. Nowhere else in the Arctic do congregations of polar bears regularly occur of the magnitude experienced at Churchill.

In addition to the well-known destinations, tourism has been developing gradually at numerous other sites in the Arctic and, indeed, is often sought as a new form of income in the mixed economy communities looking for incoming cash flows (Notzke 1999) and in regions where other forms of industry have declined. A number of studies suggest there is local support for tourism growth, provided it meets particular requirements related to community interests (e.g. Nickels *et al.* 1991; Johnston and Viken 1997; Dressler 1999).

Climate change has been seen as having a direct effect on tourism numbers in the Arctic. Increasing tourism is seen as a potential outcome of warming in particular (Kochmer and Johnson 1995). Although this possibility is attractive to many individuals and communities, it brings concomitant concerns about how Arctic tourism can be integrated, for example, with the reality of an animal harvesting lifestyle (Wenzel 1995). Nunavut communities that are close to the natural attractions of protected areas may see increased visitation as tourists seek mountain climbing, hiking and bird watching, but they must address the varied costs of shielding visitors from animal harvesting activities (Wenzel 1995). As attractive as increased tourism might be, it nonetheless represents an economic, social, political and environmental agent of change that must be addressed within the context of a particular community.

Climate change and polar tourism

A number of authors have examined the likely impacts of climate change on tourism. Brotton *et al*. (1997) explored the possible impacts of climate change scenarios for the sub-Arctic Nahanni National Park Reserve and for caribou hunting activities in the region. Their analysis indicates little change for river recreation activities in Nahanni stemming from an increase in temperature and increased precipitation, but possible changes in visitor experiences related to increased forest fires and ecological shifts associated with warmer temperatures (see also Staple and Wall 1996). Although the overall tourist season might be lengthened, this might be offset by closures due to forest fire hazard. Further scenarios suggest a possible decrease in caribou hunting as a result of climate change-related stresses on the animal population. The authors suggest that it may well be that consumptive activities are more likely than non-consumptive activities to be negatively affected because of their requirements for a specific resource rather than a general setting. Brotton *et al*. (1997) note that changes in attractions and in opportunities for recreation will result in further alterations to natural ecosystems through increased pressure and new requirements for infrastructure.

Weller and Lange (1999) report on the magnitude of expected changes on tourism in the Arctic. They note expectations of low impacts on tourism from changes in precipitation, sea ice, hydrology, plant mortality, animal distribution and animal migration. Expectations of medium impacts on tourism are noted from changes in air temperature and animal productivity. These expectations are given for the region as a whole.

Pagnan (2003) reports on discussions with Arctic tourism professionals that provide some sub-regional distinctions. In Alaska, for example, tourism professionals have observed changes in bird and whale migrations, melting ice, permafrost degradation and sparseness of snow. These changes have had immediate and practical implications for the tourism industry related to tourism attractions, experiences and accessibility. The season is being extended for activities such as cruise ship tourism and whale watching. Greenland officials reported disappointment on the part of visitors whose expectations of ice features and ice-dependent wildlife were not met because of a lack of ice along the west coast. Although not all tourism officials could confirm changes in climate that affected tourism, all were willing to have further discussions on the topic. Pagnan concludes that the environmental outcomes of climate change could have dramatic impacts on tourism and that the industry is not ready to respond. He also points to challenges related to infrastructure, access and attractions that must be addressed.

The final section of this chapter describes some of the opportunities and challenges for tourism as a result of environmental changes.

Tourism infrastructure and the polar regions

Infrastructure in the Arctic is particularly vulnerable to climate change. As sea ice continues to decline, open water will increase, causing greater and more frequent storm surges and an acceleration of shoreline erosion. This poses problems for communities and transportation infrastructure located along the coast, including facilities used for tourism. The outcomes of permafrost melting and instability are also of concern. The varied nature of infrastructure across the Arctic makes it difficult to generalise beyond this.

In the Antarctic, there is little dedicated tourism infrastructure. Most tourists arrive via cruise ship; a much smaller number arrive by independent yacht or by air. The blue-ice runways that are used to land the latter group and the temporary camps that support them are seasonal infrastructure. Given the location in the interior of the continent, where warming has not been observed, there might be little to no impact on this infrastructure. In the Peninsula, where warming and related effects are confirmed, scientific bases that might support tourism to some degree could be affected. With very little permafrost throughout the Antarctic and sub-Antarctic, and a few highly exposed sites used for scientific bases, any further examination must be on a site-specific basis.

Tourism access and the polar regions

One of the most important changes evident in the Arctic is the decline in the extent of sea ice. The number of days per year that the Northern Sea Route will be navigable is projected to increase from the current 20–30 to 90–100 days by 2080, with even more navigable days for vessels with ice-breaking capability (ACIA 2004). The Northern Sea Route has been used for tourist voyages. For example, in the summer of 1999 a nuclear icebreaker travelled to the North Pole with tourist passengers, and in 2000 there were two similar voyages (Brigham 2001). The Northwest Passage, through the Canadian Arctic Archipelago, will also be freer of sea ice for more of the summer, leading to increased opportunities for cruise ship tourism. Although the decline in sea ice will provide more open water for navigation, there might be additional hazards to navigation through an increase in iceberg calving and through the instability of what pack ice remains. It is possible that the Northwest Passage could become less predictable for shipping because of high year-to-year variability in sea ice (ACIA 2004). Nonetheless, it seems inevitable that cruise tourism will increase to most destinations, perhaps even on the scale already seen in Svalbard. The primary challenge to such an increase is an infrastructural one for much of the Arctic. Small communities have difficulty now in accommodating the needs of cruise tourists when ships visit their communities. Without substantial capital input, the opportunities will be hard to access.

In the Antarctic Peninsula, financial and physical access have increased in recent years as capacity has been expanded and lower-cost opportunities been made available. With numbers of cruise ship visitors approaching 20,000, there will be increasing competition for access to sites, particularly the top sites that currently receive the highest visitation. How warming will affect these key sites is an important and pressing question for the industry and it can only be answered by detailed site-specific studies. Will warming and increased precipitation affect snow and ice conditions at landings? Will sites become dangerous because of changes in snow and ice? Will there be increased competition among animal and bird species at these sites, and subsequent greater conflict with human users?

Tourism attractions and the polar regions

There will be climate-related changes to attractions in both polar regions. Particular activities can expand or shrink depending on the local outcomes of environmental change. For example, where snow accumulation increases in the Arctic, snow-based activities could grow; where snow accumulation lessens or becomes more variable year-to-year, these activities could decline or require greater investment in snowmaking technology. Seasons might shorten or lengthen; some activities might disappear. Changes in wildlife will have an influence, perhaps leading to new opportunities as species migrate in new patterns or are concentrated in new localities. Predictions of polar bear decline, behaviour changes and the possible disappearance of the species illustrate the degree of gravity for the wildlife viewing component of the industry.

Scenic attractions will change, resulting in site-specific as well as regional challenges or opportunities. Pagnan (2003) points out that the tourism industry in the Arctic relies on traditional perceptions of the Arctic environment and expectations about the experience that relate to ice and snow, mountains and tundra, and wildlife. As the Arctic changes, general perceptions used to sell tourist travel will change. What will it mean for tourists when the inaccessible becomes accessible, and the 'inhospitable' climate appears more hospitable? How important is the idea of an ice and snow-covered, challenging environment to expectations and satisfaction? How will a decline in polar bear populations and other typical Arctic wildlife affect tourism? Shifts and variability in biology and physical geography will affect how attractions are perceived. If tourist numbers continue to grow, related in part to changing environmental conditions, perceptions of crowding may well begin to replace perceptions of solitude. This could have devastating impacts for the Antarctic brand especially.

Adaptation and the future

This chapter has described the predicted and observed environmental changes attributed to climate change, and outlined some of the key challenges for the tourism industry in terms of infrastructure, access and attractions. There is some anecdotal evidence of tourism already being affected by changes in the environment. The ability of individuals and communities to respond adequately to challenges will be tested over the next decades. Opportunities exist for new activities, replacement and diversification, in short, for tourism operators, the communities and tourism officials to moderate the negative and benefit from the positive. Threats exist and there will be site-specific circumstances that result in some individuals and communities being unable to adapt. The vulnerable communities or segments of the industry are those whose local or business conditions do not currently demonstrate the capacity to change or support the flexibility to respond to changes that, in some cases, will be rapid and dramatic.

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3

Mountain Regions and Tourism: Impact of Global Environmental Change

Daniel Scott

Introduction

Mountain regions represent approximately one fourth of the Earth's terrestrial surface and contain some of the most diverse and fragile ecosystems. The international community recognised the importance of mountain regions in the global environment–development agenda at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, when mountain regions were included as a specific chapter in Agenda 21, thereby receiving equal priority with deforestation, desertification and climate change. The importance of mountains in the global ecosystem was also emphasised with the United Nations declaration for the year 2002 as the International Year of Mountains.

The pristine landscapes and biodiversity that make mountain regions important for the global environment are among their principal attractions for tourism. After coasts and islands, mountains are the most important destinations for global tourism, constituting an estimated 15–20 per cent of the global tourism industry (Price *et al*. 1997). Tourism is of great economic importance to many mountain communities and is one of the fastest growing economic sectors for mountain regions of the world.

Mountain ecosystems are also among the most vulnerable to global environmental change. A number of reviews of the effects of global change in mountain regions around the world (Price 1999; Beniston 2000) and the science documenting ongoing environmental change in mountain regions (glacial retreat, melting permafrost, elevation of treeline, changes in species composition, non-native species introductions, increased geomorphic processes) is progressing steadily.

Climate change is the most important and widespread form of global change affecting mountain regions. The threat of global climate change to mountain regions was recognised in the second assessment of the United Nations' Intergovernmental Panel on Climate Change (IPCC 1995), when an entire chapter was devoted to the impacts of climate change in mountain regions. Although tourism was identified as one of the sectors where important consequences were possible – along with water, biodiversity, agriculture and forestry – virtually no research was available upon which to assess the potential magnitude of climate change impacts for tourism in any mountain region of the world. More recently, the World Tourism Organization (WTO) also recognised the relative vulnerability of tourism in mountain regions to climate change when it identified the impacts of climate change in mountains as one of four main theme areas at the first international conference on climate change and tourism (Djerba, Tunisia) in 2003.

This chapter will concentrate on two of the predominant tourism segments in mountain regions, which are also the better researched areas of environmental change and tourism in mountain regions: skiing and nature-based tourism. By concentrating on these two major segments of mountain tourism, contrasts in the potential implications of environmental change for winter and summer tourism can be examined. The chapter is organised into winter and summer tourism sections accordingly.

The sustainability of winter tourism, and the ski industry in particular, has been repeatedly identified as highly vulnerable to global climate change (Wall 1992; IPCC 2001; WTO 2003). The multinational research literature on climate change and skiing is perhaps the best developed in the tourism sector, with some of the earliest studies conducted in the late 1980s. The section on winter tourism will review the findings of studies from seven nations and consider the relative vulnerability of major ski regions around the world (Europe, North America, Japan and Australia). The methodologies employed in these studies will also be examined in order to discuss their comparability.

Nature-based tourism is a very important component of tourism in mountain regions of the world and is one of the fastest growing tourism market segments globally, increasing at an annual rate of 10–30 per cent according to Carter *et al.* (2001: 266). Nature-based tourism in mountain regions is likely to be affected by climate change in two ways, altered seasonality and changes in the physical landscape. Because of severe winter conditions nature-based tourism is highly seasonal in most mountain regions. Therefore, an extended summer season could provide new opportunities for this tourism market. A study of the nature-based tourism market found that the natural setting was the most critical factor in the determination of a quality tourism product (HLA and ARA 1995). It is increasingly recognised that the value of the mountain landscape for tourism depends not just on the presence and quality of tourism infrastructure, but also on the quality of the mountain landscape. Consequently, if climate change adversely affects the natural setting (for example, loss of glaciers, reduced biodiversity, fire or disease impacted forest landscape, reduced snow cover) at a destination, the quality of the tourism product could be diminished with implications for visitation and local economies.

In many mountain regions of the world, parks and other types of protected areas are key resources for nature-based tourism. The second section of this chapter will compare the results of very recent studies on the implications of climate change and related environmental change on nature-based tourism in some of the internationally renowned national parks in the Rocky Mountains of Canada and the USA. Unfortunately, no comparable research has yet to be conducted in other mountain regions of the world.

Climate change and winter tourism: are billions at risk?

Winter tourism has been repeatedly identified as vulnerable to global climate change due to diminished snow conditions required for the sports (alpine and nordic skiing, and snowmobiling in North America) that dominate the winter tourism market. The alpine ski industry is largely concentrated in the mountainous regions of the world and has received greater research attention because of its large economic value in some regions. While it is difficult to compare the economic size of the ski industry around the world, because of the differences in the way ski resorts are operated – single or multiple owners of ski lifts, mountain restaurants and accommodations, ski schools, retail operations – and the quality of data, direct revenues from the global ski industry approach US$9 billion each year. In the USA, members of the National Ski Areas Association (NSAA) had revenues of over US$3 billion in 2003 (NSAA 2004). In 2003, the ski industry in Canada reported annual revenues of approximately US$647 million (Statistics Canada 2003). Estimates by Lazard (2002), show the ski industry in western Europe and Japan have annual revenues of over US$3 billion and US$1.4 billion respectively. In Australia, the ski industry was worth approximately US$94 million in 2000 (KPMG 2000). How much of this multi-billion dollar winter tourism industry is at risk to climate change?

This section will provide an overview of the range of studies that have examined the implications of climate change for the ski industry. Impacts on skiing supply and demand will be discussed separately and organised according to the proportion of global skier visits (Western Europe 54 per cent, North America 21 per cent, Japan 16 per cent, Australia less than 1 per cent) not the chronology of research or the relative vulnerability of each region. Because of the climatic diversity and large distances between ski areas in regions of North America – for example, the distance between a ski resort in Quebec and California can be more than 4500km – this region will be divided into eastern and western North America.

Implications for skiing supply

The importance of snow conditions for skier satisfaction was emphasised by the research of Carmichael (1996), who found that snow condition was by far the key attribute in tourist image and destination choice for winter sports holidays. Sufficient amounts of snow (either natural or machine-made) and the inter-annual reliability of climatic conditions to provide good snow conditions are also critical factors in determining the economic success of ski resorts and ski tourism.

Measuring the impact of climate change on the reliability of snow conditions, and thus the economic viability of ski areas, has been accomplished in different ways in the research literature. Studies by König and Abegg (1997) and Elsasser and Bürki (2002) have used the concept of 'snow reliability' – which they define in Switzerland as a ski resort having a 100-day ski season (minimum 30–50cm snow depth) seven years out of ten – to assess the potential impact of climate change on the ski industry. In North America and Australia, studies by McBoyle *et al*. (1986), Lamothe and Periard Consultants (1988), Galloway (1988) and Scott *et al*. (2003, 2006) have calculated the change in average ski season, which is defined as the number of days a ski area would be operational by meeting specified climatic criteria – minimum snow depth, suitable snow conditions and temperature range – to assess the potential impact of climate change on the ski industry.

The methodology – snow modelling approach, climate change scenarios used, consideration of snowmaking – and results of these and other climate change impact assessments of the ski industry are discussed below and summarised in Table 3.1.

Western Europe

König and Abegg (1997) examined the impact of three consecutive snow-deficient winters (1987–88 to 1989–90) in Switzerland as potential climate change analogues. They found the number of skiers transported by four ski resorts in the Canton and Grisons regions declined, while skier visits to high elevation glaciers increased. König and Abegg's analysis of the impact of a hypothetical 2°C warming on the snowline in the Swiss Alps indicated that the number of 'snow reliable' ski areas (using a 100-day criteria) dropped from 85 per cent to 63 per cent. By comparison, the DJF climate change scenarios for the central Alps in the ACACIA (2000) project indicated warming of 0.9–2.0°C in the 2020s, 1.4–3.7°C in the 2050s, and 1.7–5.7°C in the 2080s. Elsasser and Bürki (2002) later indicated that the number of snow reliable ski areas in Switzerland could drop to 44 per cent if the snowline were to rise to 1800m above sea level (masl), although the climate change scenario responsible for such a shift is not identified. The snow modelling methodology (from Foehn 1990) used for these studies was not described and cannot be compared to other studies.

In Austria, Breiling and Charamza (1998) developed a statistical model of monthly temperature, precipitation and snow cover depth at climate stations across the country and estimated that changes in snow cover from a hypothetical 2°C warming (with no change in precipitation) could put several major low elevation resorts (including Kitzbühel) at risk. Their study estimated the resulting losses in winter tourism revenue at 10 per cent. With various economic multipliers included, the projected losses approached 30 per cent (or roughly 1.5 per cent of Austrian GDP).

Harrison *et al*. (1999) examined the trend in ski season length at the Cairngorm ski area in Scotland from 1972 to 1996. The ski season was getting shorter on average, but the highest elevation ski lift (1060–1150 masl) indicated no change. Using a spatial statistical model of monthly frequencies of frost and days with snow cover, Harrison *et al*. used the analogue winters of 1985–86 and 1988–89 – respectively rated severely cold and exceptionally mild in their Winter Severity Index – to map the difference in days with snow cover. They observed that the warm analogue had the smallest reduction in

Table 3.1 Comparison of climate change impacts on the ski industry[a]

Region and study	*Snowmaking incorporated*	*Climate change scenarios used*	*Loss of ski season (~2050s)*	*Other impacts*
Western Europe				
Switzerland – König and Abegg (1997)	No	+2°C, no change P[b]		snow reliable[c] ski areas drop from 195 to 145
Austria – Breiling (1994)	No	+1.5°C, no change P	–15 days	
Eastern North America				
S. Ontario – McBoyle *et al*. (1986)	No	+3 to +5°C, +9% P[d]	–40 to –100%	
Quebec – Lamothe and Periard (1988)	No	+4.5°C, –15% P[d]	–42 to –87%	
S. Vermont – Badke (1991)	No	+3 to +6°C, +5% to +10% P[d]	–56 to –92%	
S. Michigan – Lipski and McBoyle (1991)	No	+3 to +5°C, +9% to +11% P[d]	–59 to –100%	
S. Ontario – Scott *et al*. (2005a)	Yes	+3.6 to +8°C, +15% to +19% P[e]	–8 to –46%	[f]
Quebec – Scott *et al*. (2005a)	Yes	+4 to +7.8°C, +14% to +35% P[e]	–4 to –32%	[f]
S. Michigan – Scott *et al*. (2005a)	Yes	+3.3 to +7°C, +4% to +16% P[e]	–12 to –65%	[f]
S. Vermont – Scott *et al*. (2005a) N. Vermont – Scott *et al*. (2005b)	Yes	+4 to +6.3°C, +4% to +22% P[e]	–14 to –60% (400 masl) +1 to –30% (1200 masl)	[f]

Region and study	*Snowmaking incorporated*	*Climate change scenarios used*	*Loss of ski season (~2050s)*	*Other impacts*
Japan				
Fukuskima *et al*. (2003)	No	+3°C, no change P		–30% skier visits nationally, –50% in southern regions
Australia				
Galloway (1988)	No	+2°C, –20% P	–64 to –81%	
Köenig (1998)	No	+1.3°C, –8% P +3.4°C, –20% P		snow reliable[g] ski areas drop from 8 to 5 drop from 8 to 0
Hennessy *et al*. (2003)	Yes	2050s: +0.6 to +3°C, +2% to –24% P[h]		potential volume of snowmaking –27 to –55%

[a] although Scott *et al*. (2003), Hennessy *et al*. (2003) and Scott *et al*. (2006) provide impact projections for the 2020s as well, only the more common 2050s results are included in this table for comparisons.

[b] P = precipitation.

[c] using '100 day' criteria.

[d] IS92a-based equilibrium GCMs.

[e] five SRES-based GCMs.

[f] other modelled outputs not summarised here include probability of operations during key holiday periods, volume of snowmaking required, water use, snowmaking costs.

[g] using '60 day' criteria.

[h] SRES-based CSIRO GC.

snow cover and concluded that ski areas above 1000m would still have sufficient natural snow cover for skiing in warmer winters. Unfortunately, it was not indicated how much warmer the 1988–89 winter was, so it cannot be compared against climate change scenarios for this region.

Eastern North America

Like Switzerland, some ski areas in North America have faced challenging climatic conditions in the late 1980s and more recently the late 1990s. Figure 3.1 demonstrates the impact of inter-annual climate variability on the length of ski seasons in the three eastern ski regions of the USA from 1975–76 to 2001–02. The tremendous variability in the 1970s preceded the widespread implementation of comprehensive snowmaking in these regions.

Some of earliest research on the potential impact of climate change on the ski industry was conducted in eastern North America (Table 3.1). McBoyle *et al.* (1986), using the equilibrium IS92a based climate change scenarios of that period (GFDL and GIS model runs from 1984), estimated that the ski season in southern Ontario would contract substantially or possibly be eliminated – 40 per cent to 100 per cent reduction. Using similar methods, a study by Lamothe and Periard Consultants (1988) projected that the number of skiable days in southern Quebec would decline by 50–70 per cent. Comparable results were also projected for ski areas in the eastern USA. Lipski and McBoyle (1991) estimated that the ski season in central Michigan would be reduced by 30–100 per cent and Badke (1991) estimated a 56–92 per cent reduction in average seasons in central Vermont.

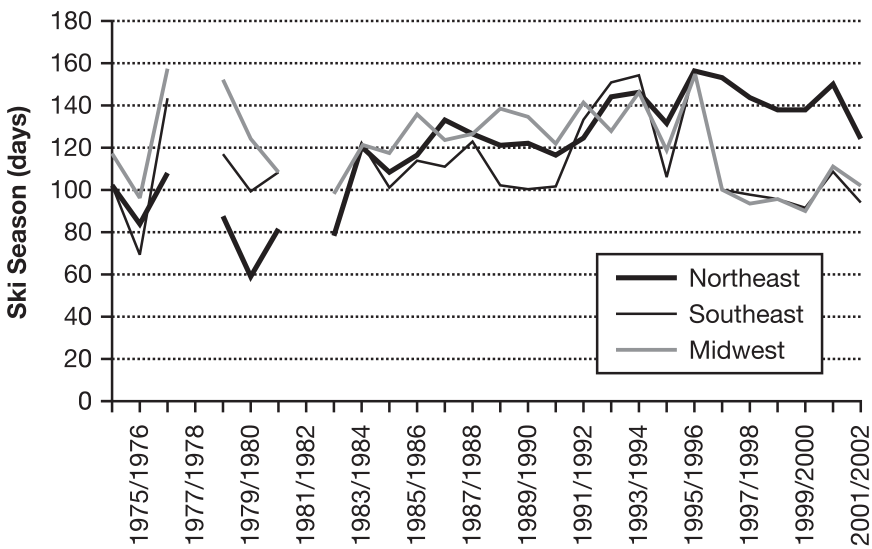

Figure 3.1 Historic ski season variability in the eastern USA

Data sources: National Ski Area Association state of the ski industry reports (1975–2002)

These early studies of climate change and skiing in eastern North America had two fundamental limitations. The first was the criteria used to define a skiable day. The criteria were based on the work of Crowe *et al.* (1973), who defined the minimum snow depth for ski operations as 2.5cm. No downhill ski area in Canada or in the world will operate with such little snow because it is unsafe and will cause damage to both ski equipment and the landscape. The second critical limitation was the omission of snowmaking as a climate adaptation strategy. Snowmaking has been an integral component of the ski industry in eastern North America for more than 20 years, as ski areas in eastern Canada and the mid-west, north-east and south-east regions of the USA have made multi-million dollar investments in snowmaking technology in order to reduce their vulnerability to current climate variability. Today, all ski areas in the north-east, south-east and mid-west ski regions of the USA and the eastern provinces of Canada use snowmaking to some extent (see Chapter 15 for a more detailed discussion of snowmaking as a climate adaptation).

A second generation of climate change assessments on the ski industry of this region emerged, reflecting the integral nature of snowmaking in the ski industry of eastern North America (Scott *et al*. 2003, 2006). These studies benefited from new transient climate change scenarios and downscaling techniques – weather generator parameterised to local climate stations – that allowed for the development of a methodology that used a physically based daily snow cover model at its core. These studies were also the first to incorporate snowmaking into the climate change assessment by integrating a snowmaking module, with climatic thresholds and operational decision rules based on interviews with ski area managers, directly with the snow cover model.

Using a range of climate change scenarios, Scott *et al*. (2003) found that, with current snowmaking capabilities, doubled-atmospheric CO_2 equivalent scenarios (~2050s) projected a 7–32 per cent reduction in average ski season in southern Ontario. The findings demonstrated the importance of considering snowmaking in climate change impact assessments, because the vulnerability of the ski industry was reduced substantially relative to previous studies that projected a 40–100 per cent loss of the ski season in the same study area (McBoyle *et al.* 1986) (Table 3.1). The authors recommended that similar reassessments be completed in areas of eastern North America where previous, and widely cited, climate change studies projected very large impacts on the ski season. Scott *et al*. (2006) examined how current snowmaking capacity affects the climate change vulnerability of ski areas in six locations in Ontario, Quebec, Vermont and Michigan where previous climate change assessments did not incorporate snowmaking. Consistent with the southern Ontario reassessment, the range of season losses projected for the 2050s were much lower (Quebec –4 to –32 per cent, southern Michigan –12 to –65 per cent, southern Vermont –14 to –60 per cent, and northern high elevation Vermont +1 to –30 per cent) than earlier studies that did not account for snowmaking (Table 3.1). At most locations examined in the reassessment, the losses projected under the 'worst case' 2050s scenario approximated the 'best case' from earlier studies.

Western North America

The Rocky Mountains are home to some of North America's most widely known winter tourism destinations. Although snow cover modelling in the mountains of north-western USA projected a 75–125cm reduction in average winter snow depth under two climate change scenarios and an estimated upward shift in the snowline from 900masl to 1250masl (US National Assessment Team 2000), the implications for major ski areas in the region have not yet been comprehensively examined.

Australia

Galloway (1988) used both a statistical model of snow cover and a physically based snow model to examine the impact of a hypothetical 2°C warming and 20 per cent reduction in winter precipitation for Australia's three main ski areas (Perisher, Hotham and Mt Selwyn). It was projected that the mean duration of their snow season would decline from 130, 135, and 81 days respectively to 60, 60, and 15 days (a 64, 66 and 81 per cent loss respectively) (Table 3.1). Unfortunately, the criteria defining the 'snow season' were not defined (i.e. duration with 5cm, 30cm or 50cm), limiting the comparability to other studies. The author also noted that the ski industry had installed snowmaking systems at these locations, but did not attempt to integrate snowmaking into the analysis.

A more recent study in Australia did examine the implications of climate change for snowmaking in Australia's Snowy Mountains. Using a physically based snow model linked with a snowmaking module (similar to the work of Scott *et al*. 2003, 2005 in North America) Hennessy *et al*. (2003) examined the potential impact of two climate change scenarios from the CSIRO Global Climate Model (GCM) at six ski area locations. Their analysis found that the potential volume of machine-made snow could be reduced by 4–10 per cent in the 2020s and 27–55 per cent in the 2050s. Considering the target snow depth required by ski area managers, it was concluded that, with sufficient investment in snowmaking systems, the six ski areas examined would be able to cope with the impact of projected climate change until at least 2020.

Other ski regions

It should be noted that no climate change assessments of the ski industry in Spain, Eastern Europe and China have been conducted; yet these are the regions with the greatest growth in the industry (Lazard 2002).

Implications for skiing demand

Although most climate change impact assessments of the skiing industry have focused on potential changes to the ski season (supply), the potential impact on skiing demand is also very important. Like studies of the impacts of climate change on skiing supply, different methodologies have been used to examine the potential impacts of climate change on skiing demand. The different research approaches and the findings of each study are summarised below.

Europe

Bürki (2000) conducted a survey to investigate how skiers at five Swiss ski areas perceived the threat of climate change and how they would change their skiing patterns if climate change conditions were realised. Relevant to the future of skiing demand, skiers were asked: 'Where and how often would you ski, if you knew the next five winters would have very little natural snow?' The majority (58 per cent) indicated they would ski with the same frequency – 30 per cent at the same resort and 28 per cent at a more snow reliable resort. Almost one-third (32 per cent) of respondents indicated they would ski less often and 4 per cent would stop skiing altogether. With more than one-third of the sampled ski market skiing less or quitting, the implications of climate change for skiing demand in Switzerland are significant. No similar surveys have been conducted in other European nations, so it is uncertain whether these results can be generalised to the European ski market.

Eastern North America

Another method of examining skiers adaptation to future climate change is to examine how they respond to shorter ski seasons during warmer winters. This approach offers advantages over surveys in that it is based on the observed behavioural responses of the entire ski market to real climatic conditions, not stated behavioural responses of a sample of the ski market to hypothetical climatic conditions. Ideally, this analogue approach would examine the difference between skiing demand during winters representative of normal current climatic conditions and winters that might represent what a normal winter is expected to be like under a changed climate, and would be conducted over a relatively short period of time when economic conditions and market competition are very similar.

The winters of 2000–01 and 2001–02 in eastern North American provided the contrast needed for such an analysis. The winter of 2000–01 had temperatures fairly representative of the 1961–90 normal in southern Ontario, southern Quebec and many of the New England states. The winter of 2001–02 was the record warm winter throughout these same regions and approximated the temperatures expected of a mid-range 2050s scenario (i.e. approximately 4.5°C warmer than the DJF 1961–90 normal). Analysis of the difference in skier demand during these contrasting winters, revealed consistently lower demand in the 2050s analogue (2001–02): –11 per cent in the Northeast ski region of the US, –7 per cent in Ontario, and –10 per cent in Quebec (NSAA 2004, Canadian Ski Council, 2004). Although this finding is not surprising, what is somewhat surprising is how small the reduction in demand during this 2050s analogue season was.

One possible explanation for this lower than expected decline in skiing demand is behavioural adaptation by skiers. In a shorter ski season skiers can participate more frequently and still ski as much as they would in a normal year (i.e. go skiing every weekend instead of every two weeks). This type of behavioural adaptation is particularly possible in a ski season that starts later than usual, because skiers know they will be likely to have fewer opportunities that season. This type of behavioural adaptation by skiers can be seen in a measure of asure of the ratio of actual skier visits to the physical capacity for skier visits at a ski area over the ski season – calculated as the daily visitor capacity times number of days of operation. The trend line in Figure 3.2 indicates that utilisation decreases during longer ski seasons. Greater utilisation during shorter ski seasons suggests that behavioural adaptation by skiers is indeed occurring in this region. Notably, similar relationships between season length and utilisation were found in the south-east and mid-west ski regions of the USA.

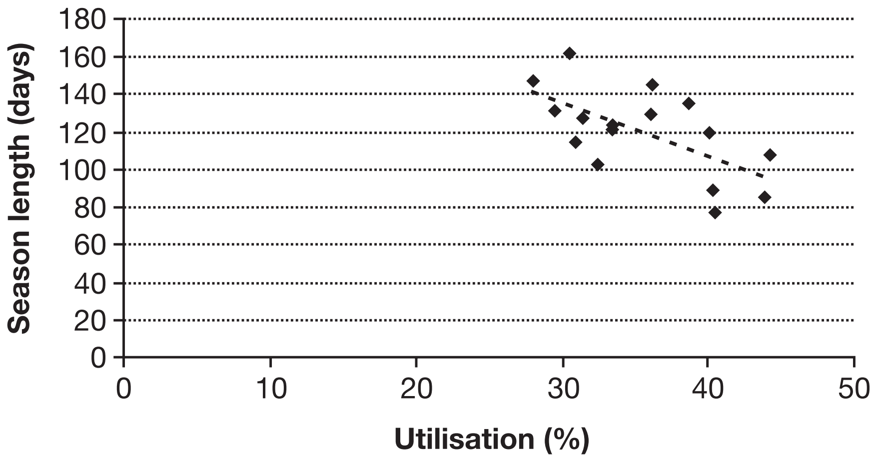

Figure 3.2 Ski area utilisation in the northeast ski region (1974–75 to 1995–96)

Data sources: National Ski Area Association state of the ski industry reports (1975–1996)

The results of this analogue approach stand in contrast to the changes in demand projected by the surveys in Switzerland and Australia, although it must be stated that, because this 2050s analogue winter occurred for only one winter (not five in a row) and was buffered by the presence of snowmaking (not natural snow only), the situations skiers were responding to are not directly comparable. Nonetheless, explaining the differences in the findings of this analysis and those of climate change and skiing demand in Europe, Japan and Australia provide interesting avenues for future research.

Japan

Fukuskima *et al*. (2003) developed a statistical model of snow depth and skier demand in order to examine the potential impact of climate change on the Japanese ski industry. Using a snow model to project future snow cover depth, their assessment of the national ski industry (61 ski areas) estimated that a 3°C warmer scenario would result in an overall 30 per cent decline in skier visits. Ski areas in southern regions were the most vulnerable with skier visits falling by 50 per cent. Conversely, the impact of climate change was projected to be negligible in some northern high altitude ski areas.

Recognising that different relationships between snow conditions and skiing demand may exist in different regions of the world, predicting skier demand based on snow depth at a ski area is a somewhat questionable approach. Most ski areas will not even open until a safe snow base is in place (usually at least 30cm). Therefore, there can be no relationship between visitation and snow depth when there are low amounts of snow. Once a safe operating snow depth is achieved and a ski area opens, there is often a surge of demand in the early part of the new ski season. This initial surge of demand occurs when snow depth levels are still relatively low compared to later in the season. Furthermore, skiers will generally not know whether the snow base is 30cm or 100cm as long as there is full coverage of the ski slope. Only if there are bare patches on the ski slope might skier visitation be affected by snow depth. In other words, the relationship between skier visits and snow depth is thought to be almost binary, with the snow depth either suitable for operations or not. The quality of snow conditions – well groomed, fresh powder snow, icy – is known to have an important impact on skier visitation, but good quality snow conditions are not dependent on snow depth once a safe operational depth has been achieved. More studies using the Fukuskima *et al*. (2003) approach are required to test for similar relationships in other ski regions.

Australia

At the same time that Bürki (2000) conducted his survey of skiers and climate change in Switzerland, König (1998) conducted a very similar survey at three Australian ski areas. Skiers were similarly asked how often and where they would ski if the next five winters had little snow cover. Only 25 per cent of respondents indicated they would continue to ski as often in Australia. Nearly one third (31 per cent) of the sampled ski market would ski less often, but still in Australia. An even greater portion of the sampled ski market would be lost to the Australian ski industry, with 38 per cent of respondents indicating they would substitute destinations and ski overseas (mainly in New Zealand and Canada) and a further 6 per cent of the market would quit skiing. With 44 per cent of the ski market potentially lost and 31 per cent skiing less often, the implications of climate change for Australia's ski industry appear ominous. Whether the remaining skiing demand would be sufficient to sustain the ski industry in Australia remains an important uncertainty. Conversely, the more snow reliable ski resorts in New Zealand and Canada could potentially benefit from the demise of the Australian ski industry.

Summer tourism: opportunities and risks

A number of authors have warned of the potential negative affects of environmental change in sensitive alpine environments for mountain tourism (Wall 1992, Elsasser and Bürki 2002, Scott 2003). Unfortunately, there has been very little empirical research conducted to explore this issue. The only studies to have examined the potential implications of environmental change for mountain tourism are limited to the Rocky Mountain region of North America and consequently that region was selected as a case study for this section.

Nature-based tourism is an important component of North American tourism, and the national parks in Canada and the USA are central components of this tourism market. Eagles *et al*. (2000) estimated there were over 2.6 billion visitor days in parks and protected areas in Canada and the USA in 1996 (including over 300 million in national parks). A large proportion of park tourism in North America is concentrated in the mountain parks of western Canada and the USA. For example, approximately 65 per cent of visitation to national parks in Canada in 2000–01 occurred in the six national parks in the Rocky Mountains. The economic impact of the three mountain national parks in the Province of Alberta alone is estimated to exceed US$600 million annually (Alberta Economic Development 2000).

Tourism in the many parks in the Rocky Mountains of western North America, displays marked seasonality. Tourism in this region is constrained by climate and the concentration of tourist visitation during warm weather months suggests that a lengthened and improved tourism season could provide opportunities to increase visitation levels in parks in this region. Richardson and Loomis (2004) and Scott and Jones (2005) used regression analysis of historical monthly visitation data (1987–99 and 1996–2001 respectively) to model the current influence of climate on park visitation and project changes under climate change scenarios. Richardson and Loomis (2004) used climate change scenarios from the Canadian and Hadley Centre GCMs forced with IPCC IS92a emission scenarios for the 2020s only. Scott and Jones (2005) examined five SRES-based climate change scenarios for the 2020s, 2050s and 2080s (the same scenarios used in the skiing assessment by Scott *et al*. 2006).

The results of the two studies for the 2020s are very similar (Table 3.2), with Yoho and Banff National Parks projected to have the least increase in visitation (3–6 per cent range), Rocky Mountain and Kootenay National Parks projected to have moderate increases (7–12 per cent range), and Waterton Lakes National Park showing the greatest potential increase (10–19 per cent). These projected increases in visitation would have benefits for local economies and tourism employment near each park. Conversely, increased visitation could also exacerbate existing ecological pressures from visitors and tourism infrastructure, particularly in high visitation parks like Banff (4.5 million annually), Rocky Mountain (3 million annually), Kootenay (1.6 million annually), and Yoho (1.3 million annually).

More astounding to tourism operators and perhaps alarming to park managers, are the projected changes in visitation in the 2050s and 2080s scenarios (Table 3.2). If the findings of Scott and Jones (2005) are suggestive of the longer term effects of climate change on visitation in other alpine parks in the Rocky Mountains region, to say nothing of future increases in demand from population growth, park-based tourism economies would increase dramatically. Such large growth in

Table 3.2 Visitation to parks in the Rocky Mountains under climate change scenarios

Park	*2020s*	*2050s*	*2080s*
Banff National Park (Alberta, Canada)[b]	+4 to +6%	+8 to +23%	+10 to +41%
Kootenay National Park (British Columbia, Canada)[b]	+7 to +10%	+13 to +41%	+15 to +69%
Rocky Mountain National Park (Colorado, USA)[a]	+7 to +12%	—	—
Waterton Lakes National Park (Alberta, Canada)[b]	+10 to +19%	+18 to +65%	+21 to +107%
Yoho National Park (British Columbia, Canada)[b]	+3 to +5%	+5 to +19%	+5 to +27%

[a] Richardson and Loomis (2004); [b] Scott and Jones (2005).

visitation in parks that already report ecological stress from tourism would also necessitate intensive visitor management, including strategies such as demarketing, visitor quotas, and variable pricing for peak and shoulder demand periods.

The research into the potential impact of climate change on park visitation in the Rocky Mountains of North America summarised in Table 3.2 only examined the implications of changes in seasonality (i.e. a longer and improved season for warm weather tourism activities). These projected changes in visitation did not take into account effects of climate change-induced environmental change in these parks.

Climate-induced environmental change has already been documented in the Rocky Mountain region (Luckman and Kavanagh 2000; British Columbia Ministry of Land, Water and Air Protection 2002) and a growing body of literature indicates the magnitude of change will only increase if climate change projections for the twenty-first century are realised. Scott and Suffling (2000) identified a range of potential climate change impacts on ecosystems in the mountain parks of Canada's Western Cordillera. Vegetation modelling suggests that the Rocky Mountain region will experience both latitudinal and elevational ecotone changes, with the potential for species reorganisations and implications for biodiversity. The upslope migration of the tree line has already been documented in Jasper National Park (Alberta, Canada) (Luckman and Kavanagh 2000). Similar impacts are expected in Yellowstone National Park (Wyoming, USA), where vegetation modelling results project that the range of high-elevation species will decrease, some tree species will be regionally extirpated, and new vegetation communities with no current analogue will emerge through the combination of existing species and non-native species (Bartlein *et al.* 1997). Vegetation modelling in Glacier National Park (Montana, USA) projected a 20m per decade upslope advance of forest through 2050, with considerable spatial variation determined by soil conditions and aspect (Hall and Farge 2003). A study of mammal populations in the isolated mountain tops of the Great Basin in the western United States projected that regional average warming of 3°C would cause a loss of 9–62 per cent of species inhabiting each mountain range and the extinction of three to fourteen mammal species in the region (McDonald and Brown 1992).

Like glaciers around the world, those in western North America have been retreating over the past century. Glacier National Park (Montana, USA), which early visitors referred to as the 'little Switzerland of America', has lost 115 of its 150 glaciers over the past century and scientists estimate that the remaining 35 glaciers will disappear over the next 30 years (Hall and Farge 2003). Similar projections have been made for glaciers in Canada's Rocky Mountain parks. Climate records show that the Rocky Mountains of Canada have experienced a 1.5°C increase in average temperatures over the past century, almost three times the global average of 0.6°C. All of the glaciers in this region have shown a strong decline over the same period and glaciers less than 100m thick are expected to disappear over the next 30 to 40 years (Brugman *et al*. 1997).

The quality of the alpine environment is essential for successful tourism in mountain regions. How might the types of climate-induced environmental change detailed above affect tourist perceptions of the landscape and visitation to parks in the Rocky Mountain region? Two research projects examined this question using similar survey methodologies. Richardson and Loomis (2004) surveyed visitors to Rocky Mountain National Park, asking how their visitation patterns (number and length of stay) might change under the specified hypothetical environmental change scenarios provided. The scenarios were partially developed on the basis of climate change studies of potential ecological impacts in the park. The three future scenarios outlined a range of environmental changes, including the climate, recreation access (scenic roads and trails) and crowding, wildlife populations and vegetation compositions in the park. Two of the scenarios were based on the Canadian and Hadley Centre GCMs forced with IPCC IS92a emission scenarios for the 2020s and a third was a warmer hypothetical scenario – it was not indicated if the 'extreme heat' scenario was based on climate change projections for 2050s or 2080).

Scott and Konopec (2005) used a similar approach, asking tourists in Glacier-Waterton Lakes International Peace Park to consider three environmental change scenarios, and to indicate whether they would still visit the park and, if so, more or less frequently. The three scenarios of environmental change were hypothetical, but where possible based on biophysical climate change impact studies in the region. The three scenarios were designed to reflect the types and magnitude of change in the 2020s, 2050s and 2080s in order to examine the potential long-term effect of climate-induced environmental change on park tourism in the region. Several types of environmental changes in the park were outlined in each scenario, including: wildlife populations, number of glaciers, vegetation composition, mammal and rare plant species lost, forest fire occurrence, water temperatures, and fishing catch rate.

Richardson and Loomis (2004) found that between 9 and 11 per cent of respondents would change their visitation behaviour under the two 2020s scenarios. A larger proportion (16 per cent) indicated they would alter their visitation patterns under the 'extreme heat' scenario. The large majority indicated they would not change their visitation patterns based on the scenarios provided. The changes in visitation behaviour in the two 2020s scenarios resulted in a 10–14 per cent increase in annual visitation, while the ‘extreme heat’ scenario caused a 9 per cent loss in visitation.

Scott and Konopec’s (2005) findings for the 2020s were consistent with those of Richardson and Loomis. After considering the environmental changes outlined in scenario 1 (2020s) the vast majority (99 per cent) of respondents indicated they would still visit the park and 9 per cent indicated they would visit more often (Figure 3.3). The vast majority of respondents (97 per cent) indicated they would visit the park if the environmental change in scenario 2 (2050s) occurred, however 14 per cent of those who would still visit indicated they would visit less often. An important threshold of environmental change was reached for many in scenario 3 (2080s), where 19 per cent of respondents indicated they would not visit the park and, of those who indicated they would still visit the park, 37 per cent stated they would visit less often. With 56 per cent of respondents indicating they would not visit the park or would visit less often, substantive environmental changes later in the twenty-first century may reduce total park visitation (Figure 3.3).

This last finding provides an important qualification to the large increases in park visitation projected for the 2080s in Table 3.1. Although seasonality changes may be favourable to increased visitation, environmental change may reduce the attractiveness of the mountain landscape to such an extent that these impacts override the opportunities provided by an improved climate for tourism.

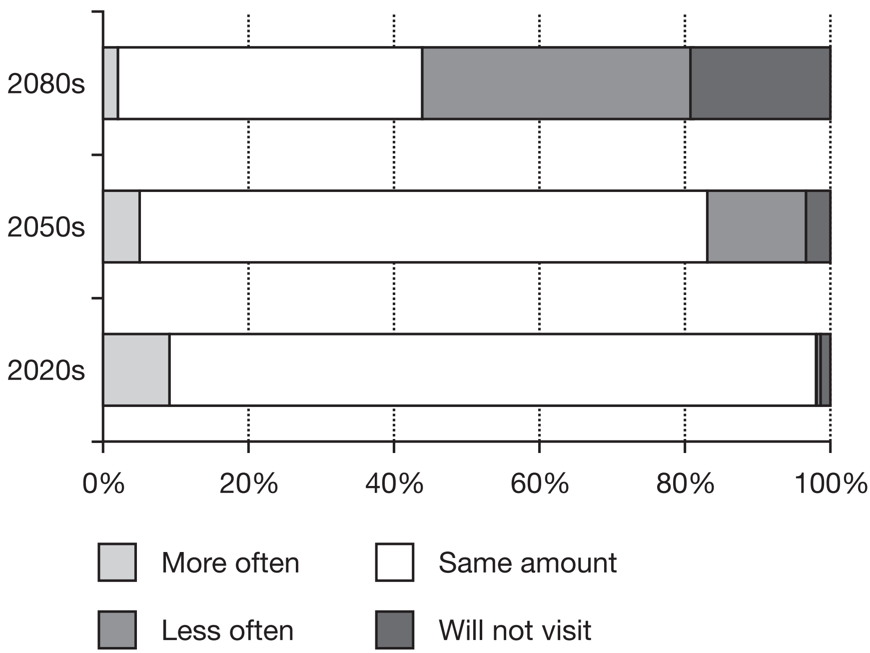

Figure 3.3 Impact of environmental change on visitation to Glacier-Waterton Lakes International Peace Park

Conclusions

This chapter has examined the potential implications of global climate change for tourism in mountain regions, with a focus on those tourism markets that have been reasonably well researched: skiing and nature-based tourism in parks and protected areas. Thus far, the geographical focus of climate change research on mountain tourism has been quite limited, with most studies focusing on the European Alps or areas of North America. Drawing a central conclusion about the implications of climate change for mountain tourism from these disparate studies is difficult. Assessing the timeframe most relevant to the tourism industry (i.e. the 2020s), it seems that a minor climatic warming, similar to that projected by the IPCC for the 2020s or even low-emission 2050s scenarios, could benefit mountain tourism in North America economically. An extended and climatically improved summer tourism season is projected to increase visitation and tourism revenues, while the projected warming is not enough to adversely affect the winter tourism season at high elevations or exceed the coping range of snowmaking in lower elevations. The sustainability of these changes – increased visitor use pressures, increased water and energy use for snowmaking – is uncertain.

Based on the available studies, this does not seem to be the case in the European Alps, however. Without the same investment in snowmaking, the European ski industry does not have the same adaptive capacity as its North American counterpart and warming of only 2°C (a high-impact 2020s scenario or only half of the high-impact scenario for the 2050s) is projected to threaten a significant number of ski areas. The potential benefit of a slightly warmer climate for mountain tourism in North America should not be construed as an argument in favour of global climate change or the abandonment of effort to mitigate climate change, but rather considered support for policies that would achieve a low emission future (i.e. an IPCC 'B2-world').

The implications of climate change for mountain tourism beyond the 2020s is even more problematic. With the substantive caveat that 'all else will remain equal' and that only the climate will change, available studies suggest winter tourism in many locations will be adversely affected by warming projected for the 2050s, while summer nature-based tourism may still benefit. The significant warming projected for the 2080s appears detrimental for both winter tourism and summer nature-based tourism. Of course, 'all else will not remain equal' particularly in the very dynamic global tourism industry. Most mass tourism markets have existed for less than 50 years and how the many major influencing variables – globalisation and economic fluctuations, fuel prices, demographic changes in existing and future demand markets, increased travel safety and health concerns, increased cultural awareness, advances in information and transportation technology, regional and local environmental limitations, such as water supply and pollution – will affect the tourism sector over the next 50 years in unknown ways. Examining how global environmental change in mountain regions may interact with other major factors influencing the tourism sector should be a focus for future research.

Research on global environmental change and mountain tourism is quite limited. Although some notable methodological developments have been made in recent years, a number of recommendations for future research are offered to conclude this chapter.

Winter tourism is one of the better-developed areas of global environmental change and tourism research. Nonetheless, there are several potential ways forward. One of the most obvious conclusions from the overview of the international skiing studies in Table 3.1 is the lack of comparability between studies. The climate change and skiing literature is sufficiently well developed that researchers, government, investors and the ski industry will want to begin to compare studies to assess the relative vulnerability of winter tourism regions. For example, in 2003 the International Olympic Committee indicated that it would include climate change in its considerations of where to hold future winter games. How will they compare the relative vulnerability of different locations to climate change? The research community needs to adopt similar terminology and standard climate change impact indicators to facilitate such comparisons. For example, calculating the average length of ski seasons and the probability of being operational during certain time periods could become the standard for impact assessments for the ski industry. These variables, because they are calculated daily, can then also be converted to regional measures of economic viability such as 'snow reliability' – whether using a 60- or 100-day rule. To facilitate future comparisons and tourism sector meta-analysis, researchers must heed the advice of the IPCC and do a better job of clearly identifying the climate change scenarios used in impact assessments.

Scott *et al.*'s (2003, 2006) reassessment of the impact of climate change on the ski industry in eastern North America, with snowmaking incorporated in the methodology, revealed a much lower vulnerability than previous studies. This research illustrates the critical importance of including adaptation in future climate change assessments in the tourism sector (see Chapters 13 to 16 for further discussion of adaptation). Similar reassessments are needed for the European ski industry. Snowmaking technology is not as widespread in the European Alps and research similar to that done in North America could provide insight into the ability of snowmaking to reduce the risk of climate change and determine in which locations the large investment in snowmaking would be justified economically.

Endeavouring to explain the somewhat contrasting results of the two approaches used to explore potential changes in skiing demand – i.e. skier surveys and skier visits during a climate change analogue year – is another interesting direction for future research in this field. If possible, both methods should be applied in the same location in an effort to compare stated and observed behavioural responses to poor snow conditions.

The findings of the studies of park visitation in the Rocky Mountain region of North America were remarkably consistent and raise many questions for future research. Will certain tourism market segments – for example first time visitors, international visitors, local recreationists, ecotourists – respond differently to environmental changes? Which environmental changes have the most impact on visitation and can adaptation strategies overcome these impacts? How might destination substitution affect regional and international tourism patterns? It is important that the future studies of tourist response to environmental change in mountain regions – or other types of tourist destinations – examine the impacts of the magnitude of environmental change anticipated later in the twenty-first century. Although it was noted that the 2020s are the most relevant to the planning and management decisions in the tourism industry, the North American studies indicate that considering only the results for 2020s would portray an overly optimistic future and would therefore be misleading about the potential long-term threat environmental change poses to tourism in some mountain regions. Of course, the findings from these North American studies cannot be generalised to other mountain regions and similar research on visitor responses to environmental change needs to be conducted in mountain regions around the world, particularly in developing nations where tourism is a vital component of local or regional economies.

The dependence on a climate-sensitive natural resource base to attract visitors places mountain tourism at greater risk to the impacts of global change than many other tourism destinations. Increased collaboration between climate change and tourism research communities, government tourism officials and the private tourism sector is paramount to advancing our understanding of the implications of global environmental change for tourism dependent economies of mountain communities.

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4

Impact of Climate Change on Water-based Recreation and Tourism

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Introduction

> On 31 January 2003, the US National Park Service released a statement indicating that it has closed another boat ramp on Lake Powell, the most popular recreation lake in the state of Utah. The ramp closure, the third of six ramps to be closed since 2002, was in response to very low water levels (24.3 metres below fill level). The pessimistic state of affairs prompted one environmental reporter to ponder, 'Lake Powell, where have you gone?'
>
> (Hollenhorst 2003: 1)

Water – recreation and tourism have an affinity for it. An extensive number of streams, rivers and natural and engineered (for example, reservoirs) lakes are critical resources for the recreation and tourism industry around the world. These water resources are the foundation of such industries as sport fishing, recreational boating, white-water rafting and diving, and indirectly support other important land-based industries including golf (irrigation) and skiing (snowmaking). These recreation activities are sensitive to natural and human-induced changes in the availability and quality of the water resources (e.g, climate change, water-level management, over-exploitation). This chapter will examine how global environmental change may affect water resources in the lakes and streams that recreation and tourism is dependent on. It is beyond the scope of this chapter to examine the breadth of impacts brought about by global environmental change. Rather, the potential impacts on water-based recreation and tourism are examined in relation to four main themes: water levels, water properties (i.e. thermal conditions, water quality), biodiversity and water supply. Case studies are drawn primarily from North America and Europe where most empirical research has been conducted to date. The case studies are from diverse regions, in North America (for example, Great Lakes, Rocky Mountains and New England) and Europe (Sweden and the United Kingdom), and are representative of the types of impacts projected to be experienced by the broader water-related recreation and tourism industries.

Water levels

In North America, the Great Lakes region has long been a popular destination for tourism and recreation – especially recreational boating and fishing – and thus serves as an important example of the implications of fluctuating water levels. Approximately six million recreational boats are registered in the region, and over one half of the 1,413 marinas in the bordering eight states and one Canadian province are located along the shores of the five Great Lakes (Thorp and Stone 2000). The recreation industry in the region is negatively impacted by extremes in both high and low water levels, particularly the latter.

A 1992 survey of marina operators and recreational boaters on the Canadian side of the lakes revealed that most had incurred some degree of financial impact as a result of fluctuating water levels since they opened for business – between five and 30 years before the survey – (Bergmann-Baker *et al*. 1993). During periods of low water levels, over two thirds of survey respondents experienced difficulty accessing docks (i.e. dock too high out of the water) and boat launch ramps (i.e. ramp no longer extended to the water). A smaller proportion experienced reductions in the length of their boating season and structural damage to wooden piers and docks. In response to these problems, marina officials undertook a number of adaptation strategies including dredging channels (55 per cent), adjusting docks (45 per cent), putting restrictions on the size and location of boats (44 per cent), and closing boat slips (27 per cent).

Below average water levels in the Great Lakes during 1999–2002 once again revealed the sensitivity of marinas and the recreational boating industry to climate variability. A 2001 survey of marinas on Lake Ontario and the upper St. Lawrence River revealed that fluctuating water levels had a 'major' or 'devastating' impact on the majority of respondents during the previous five years (McCullough Associates and Diane Mackie Associates 2002). Low water levels on Lake Huron precipitated the Canadian Government's creation of a US$9.9 million Great Lakes Water-Level Emergency Response Programme to aid marina owners and operators with emergency dredging costs (CCN 2000). Common adverse impacts among respondents were the loss of access to boat slips midseason, reductions in the ability to use equipment (i.e. refuelling hoses no longer reached boats), and the need to move boats to other marinas (i.e. with sufficient channel depths), all of which contributed to lost revenues for operators and customer dissatisfaction among boaters and anglers (Connelly *et al*. 2002).

Most climate change scenarios project reductions in average Great Lakes water levels, with reductions of at least 1m on Lakes Michigan, Huron and Erie by the middle of the twenty-first century (Mortsch *et al*. 2000). The frequency and duration of low water levels in the region are projected to increase (Mortsch *et al*. 2003), thus there is a high likelihood that marinas and recreational boaters will experience similar conditions to those experienced during 1999–2002 on a regular basis. Further, projected water level reductions are likely to contribute to reduced navigability in some channels (for example, from newly exposed sand bars, plant growth), changes in the location of well-established launch points for boats, and even restrictions on the size and weight of boats (for example, large draft sail boats) allowed to operate in certain water bodies.

Lower average water levels in the Great Lakes region will also have important implications for the nature of shoreline environments and their associated tourism potential. Many large freshwater wetlands that serve as important recreation destinations for anglers, hunters and bird watchers are vulnerable to climate change because of projected shifts in the location of shorelines. In Point Pelee National Park (Ontario, Canada), for example, lower average lake levels could cause the vitally important wetlands to dry. Since the wetland is protected by sand spits, it is likely to shift towards a meadow environment (Wall 1998), severely affecting the waterfowl population. Point Pelee is ranked among the top 10 best locations for watching birds in North America, and its waterfowl population attracts approximately 60,000 tourists annually to the park, contributing US$4 million to the local economy (American Birding Association 2003). Changes in the quality of open water wetlands will also contribute to declines in habitat (waterfowl nesting, fish spawning grounds) for recreationally valued species (Koonce *et al*. 1996; Mortsch 1998) and reductions in the biodiversity of wetland environments.

In the USA, low water levels are restricting tourism and recreation in western regions of the country and therefore serve as an important analogue of the potential impacts of climate change on tourism. Drought conditions in Colorado during the spring and summer of 2002 impacted the state's sport fishing and rafting industries. Anglers were restricted from fishing in many state rivers because the fish populations were highly stressed by low water levels and higher water temperatures. Despite the precautions, and to the dismay of anglers, higher water temperatures eventually led to large fish kills at several popular sport fishing spots on the Colorado River (Kenworthy 2002). The river rafting season was also substantially shortened. Low water levels contributed to business reductions of 40 per cent at some river rafting outfitter companies and, statewide, economic losses in the rafting industry exceeded US$50 million (Associated Press 2002a, 2002b).

The prolonged drought in western regions of the USA also negatively affected reservoirs, a major tourism and recreation resource in the country. Lake Mead is the largest functional reservoir in the western USA and is an important recreation destination in southern Nevada, used by nearly 10 million people annually (National Park Service 1999). Water levels in the reservoir have dropped nearly 30m since 1999 due to reduced flows in the Colorado River (National Park Service 2003), and were at record low levels in 2004 (Zimmer 2004). Boaters have been exposed to new navigation hazards including rocks and shifting sand bars, resulting in costly repairs to boats and safety concerns for boaters who stray from deeper waters. A number of launch ramps have been closed because they no longer extend to the water line, and new boat launch sites are exposing boaters to uneven surfaces. The National Park Service estimates that every 6m reduction in Lake Mead's surface water level costs US$6 million to mitigate (Allen 2003).

There are no known published case studies of the impact of changing water levels on freshwater lakes and streams in Europe. However, models predict substantial changes to European precipitation patterns under climate change (Xu

2000; SWECLIM 2002). Increases in precipitation, most of which is projected to occur in winter, will contribute to increased lake inflows, lake levels and runoff, the latter leading to greater frequency of riparian flooding (see Palmer and Räisänen 2002). During the summer, drier conditions, exacerbated by greater evaporation, will reduce lake inflows and lake levels. Higher temperatures and decreasing water levels in summer may also affect thermal stratification, evaporation and species composition of lakes (Hulme *et al*. 2003).

Changing water levels will also affect wetlands and floodplains of importance for tourism. For example, a 1992 review of 344 Ramsar sites showed that 84 per cent were either threatened or experiencing ecological changes through drainage for agriculture and urban development, pollution and siltation (Dugan and Jones 1993, cited in Revenga *et al*. 2000). Human modification of rivers and lakes has substantially increased in recent decades. For example, there are now more than 40,000 large dams (15m and higher) worldwide, most of them built within the last 35 years (Revenga *et al*. 2000). Dams change water levels in streams, and they can both enhance or decrease recreational opportunities. For example, reservoirs created by dams might be used for sailing or swimming, but dams might also interfere with the migratory routes of various fish species, contribute to the destruction of riparian habitat and breeding grounds, affect coastal areas and deltas through sedimentation and nutrient loads, cause changes in water temperature and chemical composition of rivers, or lead to declining water levels (Revenga *et al*. 2000). All of these factors might affect recreational activities directly or indirectly.

Water properties

A direct change in the physical characteristics of freshwater resources can indirectly affect the water-based recreation and tourism industry. In this section, the impacts on recreation and tourism are examined with respect to changes in thermal conditions and water quality.

The multi-billion dollar North American freshwater sport fishing industry (~US$75 billion, American Sportfishing Association 2002) would be impacted by changes in thermal conditions of water bodies induced by climate change. As lakes and streams warm, temperature-induced habitat loss and range shifts are expected to contribute to significant losses in recreationally valued fish populations, especially cold water species. A study by the US Environmental Protection Agency (1995) suggested that the thermal habitat for many cold water sport fish desired by anglers (for example, rainbow, brook and brown trout) would be reduced 50–100 per cent in the Great Lakes region under a doubling of atmospheric CO_2 scenario (~2050s). Under similar climate change scenarios, other studies have shown that warmer water temperatures would eliminate the sport trout fishery from most North Carolina streams (Ahn *et al*. 2000), and reduce habitat for several popular cool water sport fish in eastern Canada, including walleye, northern pike and whitefish (Minns and Moore 1992).

Similar research on the thermal habitat for salmonid species in the Rocky Mountain region of the USA found that the projected 4°C summer warming in the region would reduce habitat area by an estimated 62 per cent (Keleher and Rahel 1996). Note, however, that the response of salmon populations to climate change is not homogeneous (Levin 2003), increasing the degree of uncertainty in predicting their future distribution and abundance. The warming of water bodies would generally seem to limit the physiological tolerance of many cold water sport fish species, resulting in these species migrating to more climatically suitable waters if possible. It is projected that the range of cool water (for example, walleye, perch), and particularly warm water fish species (for example, bass), will expand northward and alter the composition of preferred catches in many lakes and streams of North America (Casselman *et al*. 2002). Magnuson (1998) suggested that the northern limit of some cold water species in the USA could migrate north as much as 500km under climate change.

The cumulative impact and regional vulnerability of freshwater sport fishing in North America to climate change has yet to be assessed, but it is possible that changes in fish species will have mixed impacts on the industry. The US Environmental Protection Agency (1995) estimated that annual losses to the US sport fishing industry from climate change would be US$320 million by the 2050s. Using an economic model, Pendelton and Mendelsohn (1998) estimated that the impact of climate change on the sports fisheries of the north-east region of the USA would range between a US$4.6 million loss and a US$20.5 million benefit, depending on the climate change scenario. Population shifts in important sport fish, especially along the southern margins of species range, are likely to negatively impact the local economy of communities that depend on particular sport fish to attract anglers. Outfitters and charter companies in Canada, however, would be likely to benefit from an increase in sport fish tourism as more American anglers would likely travel north to seek the species they have traditionally desired. In 2000, non-resident anglers (mainly Americans) spent about US$850 million sport fishing in Canada (Canada Department of Fisheries and Oceans 2002). Over the long term, however, it is possible that losses in cold water sport fisheries in many areas of North America could be offset by gains in cool water and warm water fisheries, especially if anglers adapt their preferences to changes in locally dominant species.

Changes in thermal conditions of lakes and streams would also limit the tourism potential for winter sport fishing. In the Great Lakes region of North America, Lake Simcoe (southern Ontario) is an important destination for ice fishers; the local community typically receives more winter sport fishers than summer ones and the winter sport fishery is estimated to be valued at US$17.8 million (Scott *et al*. 2002). Ice conditions, especially the timing of ice cover and ice thickness, are critical determinants of the ice fishing season. The 1997–98 ice fishing season on Lake Simcoe highlighted the future impacts the industry may experience under climate change. The winter of 1997–98 was the second warmest on record in the Great Lakes region (3.7°C above the 1961–90 normal), and the above normal temperatures contributed to a 52 per cent reduction in the fishing season on Lake Simcoe (Scott *et al*. 2002). The winter of 1997–98 was an analogue for winter in the 2050s (according to mid-range climate change scenarios); ice fishing seasons are expected to be reduced by 50 per cent in the 2050s.

Reductions in the duration of ice cover on reservoirs, lakes, streams and even canals would also limit ice-skating opportunities (Stefan *et al*. 1998, Williams *et al*. 2004). In North America, a study of spring ice-out dates on 29 lakes in New England (USA) between 1850 and 2000 found that the duration of ice cover has been reduced by nine and sixteen days in the northern/mountainous and southern regions of New England, respectively (Hodgkins *et al*. 2002). A model of 143 freshwater lakes in North America predicted that a 1°C increase in average air temperature would result in ice-in dates occurring five days later and ice-out dates six days earlier (Williams *et al*. 2004). Changes in the duration of ice cover under climate change will limit ice-skating opportunities on the world's longest outdoor skating rink (7.8 kilometres) – the Rideau Canal Skateway (Ottawa, Ontario). Skating on the Rideau Canal Skateway is a 30-year-old tradition in Canada; the skating experience is a primary attraction to the 1.5 million people that visit Ottawa's annual winter festival (Winterlude) in February, contributing over Can$100 million (approximately US$82 million) to the local economy (Ekos Research Associates 2000).

Under the three climate change scenarios examined, the skating season is expected to diminish (Table 4.1). The skating season is projected to decline from a current average of 61 days to between 43 and 52 days in the 2020s. By the middle of the century (2050s), it is projected that the skating season could be only three to four weeks. In the 2080s the season is projected to be reduced even further and virtually eliminated under the warmest scenario. Analysis from the same study concluded that the Rideau Canal Skateway would also open later. As early as the 2050s, it is projected that the canal would not open to skaters until the winter festival begins, which is four weeks later than at present.

In Europe, suitable climatic conditions for ice-skating and other ice-related activities are also likely to decline substantially (see SWECLIM 2002). Ice-skating has a long history as an important recreational winter activity in many European countries. For example, the Swedish *Stockholms Skridskoseglarklubb* (Stockholm's Ice-skating and Ice-sailing Club) was founded more than 100 years ago and has 10,000 members (SSSK 2004). The Great Dutch Ice-Skating Marathon is an example of ice-related events attracting large numbers of tourists that would be vulnerable under climate change:

Table 4.1 Projected season length of the Rideau Canal Skateway under climate change

	1961–90 (days)	*2020s (days)*	*2050s (days)*	*2080s (days)*
Current average season length for ice-skating	61			
Climate change scenarios				
NCARPCM B21		52	49	42
ECHAM4 A21		46	34	25
CCSRNIES A11		43	20	8

Source: Scott *et al*. 2005b

> Known as the *Elfstedentocht* in Dutch, the one-day tour is an obsession for its 16,000 participants and the millions more who follow it worldwide. The event is held in The Netherland's northern province of Friesland but only in those years when the ice freezes over the 124-mile track of lakes and canals that makes up the route. The last tour took place January 4, 1997. The fabled marathon was officially organized as a contest nearly 90 years ago by the Friesian Skating Association though its roots go back generations before that. This century, the race has taken place just 15 times; yet, it's become the biggest phenomenon in Dutch sports.
>
> (The Holland Ring 2004)

Thermal changes in lakes and streams will also influence water quality, which could limit the attractiveness of many water resources for tourism. Water quality influences the solubility of dissolved oxygen, the metabolism and respiration of plants and animals, and the toxicity of pollutants (Stefan *et al*. 1998: 547). Water quality is a subjective concept that depends on socially defined levels of pollution – water quality requirements for water-related recreation and tourism segments are usually high. In Europe, the water quality at many popular recreation lakes has been negatively affected by the influx of nutrients, which has contributed to eutrophication and littoral algae production (Cronberg 1999; Scheidleder *et al*. 1999). Nutrient input-related problems caused by agricultural runoff are reported in most European countries (Scheidleder *et al*. 1999; Revenga *et al*. 2000; see also Kosk 2001; McGarrigle and Champ 1999), which has had a negative effect on recreational use of water bodies (Table 4.2). For example, of 171 freshwater bathing areas in Spain, only 42 per cent met stricter – that is recommended – water quality standards in 2003. In Belgium, 47 per cent of 70 freshwater bathing areas complied with stricter quality standards and 84 per cent with mandatory standards. In Italy, 58 per cent of 775 freshwater bathing areas met recommended quality standards and 71 per cent mandatory standards. Due to very poor water quality, bathing was prohibited in almost 28 per cent of all freshwater bathing areas in Italy.

Increases in nutrient loads entering lakes and streams will also negatively affect recreational fishing. For example, some of western Ireland's recreational fishing lakes, described as 'among the finest, natural, wild brown trout fisheries in Europe' (McGarrigle and Champ 1999: 455), are threatened by the intensification of agricultural production and a concomitant influx of phosphorus. In Lough Conn, a formerly oligotrophic/mesotrophic lake, nutrient inputs have resulted in an increase in littoral algae production and the disappearance of the arctic charr (*Salvelinus alpinus*), a popular sport fish (McGarrigle and Champ 1999). The threat to population densities of popular angling fish species from nutrient inputs have also been reported in England (Eliott *et al*. 1996).

During the summer, changes in water quality induced by warming water conditions could also be a limiting factor in beach recreation. As water warms, its oxygen-carrying capacity is diminished, which can contribute to enhanced algae growth and other water pollution (Poff *et al*. 2002). Bacterial contamination can degrade the aesthetics of beaches and pose a health risk to swimmers. Under

Table 4.2 Fresh water bathing areas in Europe, 2003

Country	*Fresh water bathing areas (total)*	*Respecting stricter quality standards (%)*	*Respecting mandatory standards (%)*
Belgium	70	47	84
Denmark	113	88	97
Germany	1572	80	95
Greece	4	75	100
Spain	171	42	96
France	1405	59	94
Ireland	9	100	100
Italy	775	58	71
Luxembourg	20	40	80
Netherlands	561	64	98
Austria	266	80	97
Portugal	55	11	96
Finland	292	70	98
Sweden	404	83	99
UK	11	46	100

Source: European Union 2004

Quality parameters: total coliforms, faecal coliforms, mineral oils, surface-active substances, phenols

climate change, there is a higher likelihood that beach closures or restricted use could become more common in many popular tourism areas.

Algae growth might also affect increasingly popular recreation sports such as diving. Particularly clear lakes are usually well known by diving tour operators and divers. Although no research has been carried out in the context of lakes, reduced visibility brought about by micro-algae has been documented as an important parameter negatively affecting diving experiences in the tropics (see Gössling *et al*. 2005 for a case study in Mauritius).

Biodiversity

An estimated 12 per cent of all animal species live in fresh water (Abramovitz 1996: 7), highlighting the importance of freshwater ecosystems for biodiversity. Freshwater ecosystems are endangered through pollution, overexploitation and invasive species. For example, more than 20 per cent of the world's 10,000 described freshwater fish species might have become extinct, threatened, or endangered in recent decades (Revenga *et al*. 2000).

Floodplains and riverine wetland ecosystems are also of great importance for biodiversity (Tockner and Stanford 2002). For example, wetland-dependent mega-fauna of importance for tourism in Asia includes different kinds of monkey such as the proboscis monkey (*Nasalis larvatus*), which lives in forested riverine wetlands and sleeps in tall trees along riverbanks, leaf monkeys (*Presbytis* spp.) or crab-eating macaques (*Macaca fascicularis*). Swamp forest is an important habitat for orangutans (*Pongo pygmaeus*) in central Kalimantan/Borneo (Dudgeon 2000). In Europe, 20 per cent of regularly occurring bird species are dependent on inland wetlands and, of all bird species that are categorised as endangered, vulnerable, rare or declining, 30 per cent are inland wetland-dependent species (Revenga *et al*. 2000). Birds are of great importance for tourism and recreation all over the world. In the UK, the red grouse (*Lagopus lagopus*) is the most significant commercial wild game bird. Estimates of gross revenues received by grouse moor owners range from €4.8 million to €14 million, with participants paying between €68 and €115 per pair shot. Grouse shooting may sustain around 2,500 jobs in Britain (IUCN UK 2002).

Bird watching in the UK might be of even greater importance. In 1998/99, the Royal Society for the Protection of Birds' reserves attracted over one million visitors, generating an annual expenditure of €16.8 million. Particularly in rural areas, bird watching can be of great economic significance. For example, in the Shetland Isles, bird watchers bring an estimated €1.4 million to the local economy supporting 40 full-time equivalent jobs. In Scotland, geese are a major winter bird-watching attraction, with at least 44,000 visitors to key goose reserves each year contributing €2.4 million to local economies. The value contributed to the economy by bird watchers in the UK is estimated to be in the order of €322 million, including the purchase of equipment, bird food, membership subscriptions, travel, books and magazines (IUCN UK 2002).

The accidental introduction of non-native species into lakes and streams by human activities is an important global environmental change issue for tourism and recreation in many parts of the world. One of the most well-known examples, illustrating the consequences of invasive species introductions in freshwater systems, is Lake Victoria which is bounded by Uganda, Tanzania and Kenya. The lake contained more than 350 fish species in the cichlid family, of which 90 per cent were endemic. After introducing the Nile perch and Nile tilapia in the 1950s, more than half of the native species became extinct (Revenga *et al*. 2000). Similar consequences of the colonisation of water bodies by non-indigenous or 'invasive' species can be observed in the Great Lakes region of North America, illustrating the potential range of impacts to recreation and tourism.

Two of the most important invasive fish species in the Great Lakes are the sea lamprey and the round goby. Sea lampreys are native to the Atlantic Ocean and are believed to have entered the lake system through shipping canals in the early 1900s. They are well established in Lakes Michigan, Huron and Superior, with smaller populations in Lakes Ontario and Erie. Sea lampreys are parasitic eel-like vertebrates characterised by a round, sucker-like mouth, which it uses to attach itself to other fish. It feeds on the bodily fluids of other native freshwater fish, resulting in deep wounds/scarring and often the death of its prey. The round goby, a member of the *Gobiidae* family, is a more recent arrival to the Great Lakes, having only been detected since the early 1990s. Brought to the Great Lakes by foreign ships (from Eurasia), the main populations of round gobies are located in

Lake Erie and Lake St. Clair, but isolated pockets have been found in Lakes Huron and Michigan (Jude 1997).

Sea lampreys and round gobies threaten the native species that support the large sport fishing industry in the Great Lakes region. Sea lampreys are non-selective in their feeding, attacking many large and valuable sport fish including salmon, trout and perch. A report prepared for the Great Lakes Fisheries Commission indicated that one sea lamprey kills over 40kg of fish during its adulthood, which lasts no more than two years (Ontario Federation of Anglers and Hunters 1998). The sea lamprey contributed to the elimination of lake trout, a valuable sport fish, from Lakes Michigan and Huron during the 1960s (Schneider *et al*. 1996), and severely hindered the establishment of a salmon population introduced to the Great Lakes specifically for sport fishing (Fuller *et al*. 2004). Round gobies pose a threat because they feed on fry and eggs of native fish, a behaviour that reduces populations of native fish (Jude 1997). In addition, both species are rapid reproducers (round goby will spawn five times in one mating season), and are aggressive by nature, typically colonising the spawning grounds of native sport fish.

The accidental introduction and subsequent proliferation of non-native species threatens the valuable sport fishing industry in the Great Lakes. The feeding and reproductive actions of sea lampreys and round gobies have important implications for anglers. Population reductions in popular game fish and the inability to re-establish current populations in some areas could lead to demand shifts in sport fishing destinations, impacting the livelihoods of communities that depend on the industry. Monetary investments to rehabilitate native spawning grounds may become futile in the future, thus serving to further reduce populations of popular sport fish. It is possible that anglers will demand the introduction of new sport fish to the Great Lakes that are immune to these two invasive species, thus contributing to the creation of new hybrid sport fish varieties. Uncertainty exists regarding the effect the introduction of hybrid sport fish might have on the composition of existing sport fish populations. In addition, round gobies appear to be tolerant of poor water quality and warm water. Under climate change, projected changes in water conditions (for example, warmer water, decreased water quality) could permit existing populations of gobies to become more prolific.

Zebra mussels are another invasive species in Great Lakes' waters. Native to the Caspian Sea, zebra mussels were first identified in the Great Lakes in the late 1980s. Control of this invasive species is important because it influences a range of activities in the region's recreation and tourism industry. For example, zebra mussels can negatively affect beach recreation. Littering of beaches by dead zebra mussels that wash ashore and accumulate can diminish the aesthetics of beaches. In one event, zebra mussel shells were 0.6m thick and covered an area 4.6m wide along a 400m stretch of public beach on Lake Erie (Dane County Lakes and Watershed Commission 2003). Decaying zebra mussels also produce a foul odour that can further diminish enjoyment of public beaches and swimming areas. If the population growth and range expansion of zebra mussels continues uninhibited in the Great Lakes region, the presence of large onshore expanses of zebra mussels could also precipitate restrictions in beach use or lead to beach closures because the shells pose an additional safety threat because the razor-sharp shells can cut exposed skin.

Zebra mussels also negatively affect recreational boating. The mussels easily attach themselves to and accumulate on the hulls of boats, which can to lead to reductions in handling capability. A common problem for many recreational boaters is the accumulation of zebra mussels in water intake pipes – clogged pipes increase the risk of onboard fires due to overheated engines (Michigan Sea Grant College Program 1992). Accumulation of mussels on boats and the use of boats on different lakes also contribute to the spread of this invasive species. It is likely that difficult decisions will have to be made in the future to limit the spread of zebra mussels, decisions that may restrict where water access is granted. Wisconsin, for example, recently amended a state law to require all anglers to remove zebra mussels from any boat they put into and remove from state waters – failure to do so is punishable by fines and anglers can be prohibited from using state waters (State of Wisconsin 2002). It is possible that if other jurisdictions enact similar rules to prevent the spread of zebra mussels, recreation and tourism will be negatively affected. Boating and sport fishing in some areas may decline, and shifts to new regions where there are fewer access restrictions and less time is required for inspections and cleaning may occur.

The marine diving industry in the Great Lakes region has also been affected by the invasion and spread of zebra mussels, but the nature of the impact is mixed. There are between 6,000 and 10,000 shipwrecks in Great Lakes' waters (2000 in Lake Michigan alone) (Cigelske 2004; Migliore 2004). Many related water reserves and marine parks, including Fathom Five National Marine Park (Canada) in Lake Huron, are popular diving and water-tour destinations, and are economically important for many local communities. For example, it is estimated that the Great Lakes Shipwreck Museum in Paradise, Michigan, receives over 90,000 tourists annually, contributing approximately US$14 million in direct spending to that local economy (Migliore 2004).

Stakeholders in the marine tourism industry have mixed feelings about the impact of zebra mussels. On the positive side, diving and surface viewing conditions have been enhanced at many shipwreck sites because the water-filtering action of zebra mussels has contributed to better water clarity. In parts of Lake Erie, the mussels have actually improved clarity 77 per cent (to 6.1m) (Claiborne 2000). Continued improvements in water quality could enhance diving experiences (i.e. see shipwrecks better), provide an opportunity to expand the number of sites divers can access and reduce the need for experienced guides, or even increase surface tour operations (for example, in glass-bottom boats). On the negative side, zebra mussels are considered a threat to marine tourism. Zebra mussels are colonising many popular shipwrecks, blurring ship details and contributing to their rapid disintegration (Claiborne 2000). Marine businesses that depend on the quality of shipwrecks are likely to be negatively impacted. It is also possible that demand will shift to reserves and marine parks with less abundant zebra mussel populations, or demand will increase for deep water dive sites where the species has not yet colonised the shipwrecks.

The invasion of non-native fish species is also a problem in many European lakes popular with anglers. The English Lake District, for instance, currently contains relatively few native fish species. Illegal introductions of exotic fish species can threaten native sport fish through competition (for example, by roach, *Rutilus rutilus*), predation (for example, zander, *Sander lucioperca*; ruffe, *Gymnocephalus cernuus*), or habitat modification (common carp, *Cyprinus carpio*). This affects recreational angling of native species including sea trout (*Salmo trutta*), Atlantic salmon (*Salmo salar*), perch (*Perca fluviatilis*) and pike (*Esox lucius*) (Winfield and Durie 2004). Recreational angling is of great importance for the local tourist industry. In England and Wales, the total value of inland fisheries is estimated at £3032 million (IUCN UK 2002).

Water supply

Mark Twain once said: 'Whiskey is for drinking, water is for fighting over.' The availability of fresh water is currently an important issue for tourism operations in some locations. Water availability will increasingly be a critical issue for the sustainability of tourism as demand for water from other users (for example, industry, agriculture, cities) increases and climate change affects the reliability of water supplies (see Chapter 10, this volume).

In North America, the supply of fresh water may become a critical limiting factor in tourism and recreation, particularly in western regions. A recent US government report acknowledged that water supplies in states west of the 100th meridian were insufficient to meet current municipal, agricultural, recreational and environmental water demands (US Department of the Interior 2003). Projections of future water demand, based on population and economic growth, indicated the probability of conflicts over water supplies in many areas of the western USA. A number of areas in the western USA were rated as being at a 'high', 'substantial' or 'moderate' risk of water conflicts by 2025, with several important tourism destinations located within the high and substantial risk regions.

A number of important tourism destinations are located in areas where future conflicts over water supply are highly likely if not inevitable. Las Vegas (Nevada) is one high-profile tourism destination located in a 'high risk' zone (as defined by the aforementioned US government report) for water conflict. Las Vegas is considered one of the world's largest per capita users of water, and a large portion of the water used to support Las Vegas' tourism industry is drawn from the Lake Mead reservoir. As discussed earlier, water levels in the reservoir have dropped nearly 30m since 1999 due to reduced flows in the Colorado River (National Park Service 2003) due to the region's prolonged drought. In order to ensure water availability for tourism in Las Vegas over the next 20 years, it is very likely that difficult decisions will have to be made with respect to the regulation of existing water-intensive tourism operations (e.g. golf courses, hotels with large fountains) and possible restrictions on future tourism development in the area.

By comparison, Phoenix (Arizona) is located in a region with 'substantial' risk for water-use conflicts over the next 20 years. As an important golf and winter-getaway tourism destination, Phoenix also has a high demand for water. Municipal and federal governments and agricultural agencies possess historic water-use rights in this region and, in periods of low water availability, these historic water rights will be given priority over more recent allocations granted to the recreation sector (for example, golf). Under such a scenario, these golf oases in the desert would be unsustainable. The courses are likely to sustain long-lasting damage to turf areas very quickly with longer-term implications for tourism demand.

It is important to acknowledge that the US government's projections of water-use conflicts were based on forecasts of population and economic growth to the year 2025. The projections did not consider the potential impact that climate change would have on current water supplies and related issues. Disregarding the climate change issue is negligent given that climate change is projected to exacerbate reductions in water supplies in the region (US National Assessment 2000).

In terms of individual recreation industries, irrigation by the golf sector represents a significant demand on water in some areas of the USA. In the USA, approximately 500 billion gallons of water are drawn from lakes, streams and aquifers annually to keep fairways green (Walsh 2004) and new golf course development is booming in areas where water availability problems are already common (Florida, California, Arizona, Nevada and Texas). No known published study has examined the potential impacts of climate change on long-term irrigation needs, but water demands from the golf industry will increase, with important consequences in major golf destinations that have high course concentrations. Competitive relationships between major golf destinations (for example, Phoenix and Myrtle Beach) could also change as a result of water availability, with potential losses in areas with inadequate irrigation to sustain optimal playing conditions. Over the even longer term, limitations on water availability could eventually influence the overall design of golf courses. In the future, new golf courses may incorporate narrower fairways and permit browner roughs as a means to reduce irrigation requirements (Selcraig 1993; Walsh 2004).

Snowmaking also places a large demand on water supplies, and the associated costs typically encompass a share of operating expenses at many ski areas in North America, especially in the east (see Scott, this volume). Snowmaking permits ski areas to open earlier and close later, particularly when natural conditions are less than optimal (for example, not enough snow, mid-winter thaws). A recent study by Scott *et al*. (2005a) assessed the amount of snowmaking required to maintain ski seasons in six areas of eastern North America under several climate change scenarios. The need for snowmaking was projected to increase between 8 per cent and 66 per cent by the 2020s and between 18 per cent and 161 per cent by the 2050s.

Changes in water availability in many regions of North America will undoubtedly lead to increased competition among users, including tourism and recreation. In the western USA, nine federal lawsuits have been filed in a dispute over the priority given to water used from the entire length of the Missouri River (Boldt 2003). Upper Missouri states want the federal court to give priority to water-based tourism and recreation (for example, sport fishing), which is valued at an estimated US$66 million annually in these states. Lower Missouri states want priority given to shipping, even though its value is one tenth that of tourism. In one specific lawsuit, North Dakota Game and Fish is suing the US Army Corps of Engineers over low water levels in reservoirs that it says contributes to fish kills, thus hindering the sport fishery (Gunderson 2003). Decisions regarding the value placed on different water uses (for example, tourism, agriculture, industry) and the priority given to individual industries will become increasingly difficult in many areas of North America under climate change. The Missouri case is only one example, but it is likely that the judicial system will be asked to resolve many such water-use conflicts in the future.

In Europe, unsustainable groundwater withdrawals threaten the tourism potential of natural environments along the shorelines of lakes and streams. Table 4.3 summarises cases of groundwater exploitation from European countries for which data were available. In 33 of the 126 cases of overexploitation, wetlands were endangered. In 53 cases, saltwater intrusion resulted, particularly along the coastlines of Spain and Turkey (Scheidleder *et al*. 1999). Over-abstraction in the Republic of Moldova is causing saltwater intrusion through the rise of highly mineralized water from deeper aquifers. The main cause for over-abstraction in the Mediterranean countries is public water demand, including tourism (WWF 2001). Tourism thus contributes to over-abstraction in these areas, and is likely to suffer both directly – as the amount of available fresh water decreases – and indirectly – if there is less wetland area providing bird watching opportunities – from these developments.

Table 4.3 Endangered wetlands and saltwater intrusion

Country	*Number of over-exploited areas*	*Overexploitation leading to*	
		saltwater intrusion	*endangered wetlands*
Cyprus	7	6	1
Denmark	14	10	5
Estonia	3	1	0
Hungary	4	0	2
Latvia	3	1	3
Rep. of Moldova	17	14	0
Poland	18	3	13
Portugal	3	3	0
Romania	3	0	0
Spain	45	11	3
Turkey	9	4	6
Total	126	53	33

Source: Scheidleder *et al*. 1999

Conclusion

The chapter has shown that a wide variety of recreational activities depend on streams, lakes, reservoirs, canals and wetlands. These include bathing and swimming, recreational boating, sport fishing, golf, ice-skating and bird watching. Natural and human-induced changes are likely to affect water levels, water properties, biodiversity and water supply, and hence the very foundations that various recreation and tourism segments depend on. Increasing water temperatures, nutrient inputs and other pollution, as well as changing precipitation patterns and associated changes in river discharge and lake water levels in particular will have consequences for recreational activities. Water abstraction, land-use changes, the introduction of alien species and weather extremes may be additional stressors for freshwater systems. The North American, European and African cases examined in this chapter suggest that global environmental changes to lakes and streams will, on balance, have a negative effect on recreation and tourism, with many tourism industries and the communities that depend on them potentially experiencing substantial economic losses as water resources become more scarce and contested in the future.

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5

Forest Ecosystems for Recreation and Tourism

Stefan Gössling and Thomas Hickler

Introduction

Forest ecosystems are of major importance for recreation and tourism and attract millions of visitors every day, particularly in the mid-latitudes. Global environmental change will affect forest ecosystems through land-use changes, changing temperatures and precipitation patterns, increasing CO_2 concentrations, and nitrogen deposition (Sala *et al*. 2000). This might, in the medium-term future, have consequences for tourism and recreation. Forests, in particular in the tropics, also host a majority of the world's biodiversity (Myers *et al*. 2000), with many individual species being of great importance for tourism. As biodiversity is under serious stress through global climate change (e.g. Thomas *et al*. 2004), loss of species might also affect forest tourism. The chapter provides an assessment of global environmental change affecting forest ecosystems and outlines the consequences for tourism and recreation.

Tourism in forest ecosystems

Worldwide, forests provide attractive scenery for recreation and tourism. Mid-latitude forests in Europe and the United States, for instance, have for centuries been recognised for their recreational benefits (e.g. Carhart 1920). In countries like Austria, Switzerland, Sweden, the UK, Japan, Australia or New Zealand, they are an important element of the landscapes that attract millions of domestic and international tourists each year (see Bostedt and Mattsson 1995; McShane and McShane-Caluzi 1997; Hall and Higham 2000; Kearsley 2000; Knight 2000). In mid-latitude forests, an increasing number of consumptive and non-consumptive activities are carried out by urban populations in search of recreational spaces. Activities include, for example, walking, hiking, mountain-biking, cross-country skiing, dog-sledding, fishing, hunting, bird watching, or mushroom and berry collection (Table 5.1). Such is the level of participation in forest-based recreational activities that some authors have started to describe forests as 'sites of mass recreation' (Knight 2000: 341, in the context of Japanese forests).

In many countries, the growing importance of forests for recreation and tourism has even been an argument for promoting forest expansion (e.g. Broadhurst and

Table 5.1 Forest-based activities

• Animal and plant observation	• Orienteering
• All-terrain vehicle driving	• Outdoor education
• Bird watching	• Painting
• Caving	• Photography
• Canoeing/kayaking	• Picking mushrooms, berries, flowers and herbs
• Collection of other forest products	• Picnicking
• Cross-country skiing	• River and lake fishing
• Dirt bike driving	• Scenic drives along mountain ridges or through forests
• Dog-sledding	• Snowmobiling
• Fishing (lakes, rivers)	• Snowshoeing
• Hiking	• Survival training
• Horse riding	• Technical rock climbing
• Hunting	• Walking
• Mountain biking	• Watching animals
• Mushroom and berry collection	• White water rafting
• Nature observation	
• Nature photography	

Source: Bostedt and Mattsson 1995, McShane and McShane-Caluzi 1997, Kearsley 2000, Knight 2000, Vail and Hultkrantz 2000

Harrop 2000; Ghimire 1994). Even northern boreal forests, which are less renowned for recreation, have gained importance as hiking and adventure tourism destinations, as well as tropical rainforests, which are becoming increasingly popular as tourist destinations (Lindberg *et al*. 1998; Gössling 1999). Some of the most well-known national parks in the world, such as the Monte Verde Cloud Forest in Costa Rica or the Volcanoes National Park in Rwanda, are located in the tropics. Even though the overall number of visitors being attracted by rainforests is small, rising tourist numbers and increasing interest in nature-based vacations have turned even lesser known reserves and parks in the tropics into tourist magnets. The attractiveness of protected areas in the tropics will often be attributed to certain 'charismatic' animals and a diversity of observable, spectacular, dangerous or colourful species is a precondition for rainforest tourism (Roth and Merz 1997). However, the very term 'tropical rainforest' seems to increasingly have the potential to attract visitors because, like no other ecosystem, tropical rainforests stand for the western conception of pristine wilderness, exotic fauna and flora, and the diversity of life.

Charismatic forest fauna includes large mammals, such as any kind of monkey, jaguar, leopard or tiger, or in the northern latitudes, bear, beaver, reindeer or moose. Other appreciated animals are colourful or peculiar birds, such as hummingbirds, chameleons, lizards, iguanas, toads, frogs, snakes, ants, bats, butterflies and bugs. In Madagascar, for example, the giraffe-necked weevil (*Trachelophorus giraffa*), a tiny insect with an un-proportionally long neck, is a major attraction in the Ranomafana National Park. Species such as these also have the power to create and maintain narratives of evolution and diversity which explain part of the attractiveness of tropical rainforests.

In the northern latitudes, rather fewer species might be attractive for tourism, but these species seem disproportionally important. The moose in Northern Europe, for example, is not only a symbol of boreal forests, but a symbol of Scandinavia. Without this species – which appears in many tales and on countless souvenir items – northern forests and Scandinavia itself might lose much of their mystical power and tourist appeal. It should be noted, though, that certain species might also have the potential to scare away tourists. Ticks, for example, have become increasingly common in European forests, carrying and transmitting potentially life-threatening diseases such as tick-borne encephalitis or Lyme disease. This can be seen as a result of climate change (Gustafson and Lindgren 2001) and might make people more reluctant to visit forests. For some areas, there might even be explicit warnings (e.g. USDA Forest Service 2004).

Plants species of importance for tourism usually have aesthetic, nutritional or medical properties. In Europe, for instance, flowering plants covering forest floors attract large visitor numbers in spring, while in autumn, mushroom collection has great touristic appeal. In Japan, visitors are also known to collect herbs (Knight 2000). The structure of forest ecosystems is also of importance for tourism, as indicated by the attractiveness of certain forest types such as the Red Wood forests in the USA or the Alerce forests in Chile. Mangrove trails are popular tourist sights in the tropics, and savannah shrubs are essential elements of some African landscapes and wildlife-tourism experiences. Arboreta and botanical gardens are also important sights, often located in proximity to or within cities.

The reasons for the growing interest in forest tourism are multiple. As Urry (1995) remarks, tourism is increasingly built on the marketing of nature and the natural, which have become central elements of travel. Nature has, in many contexts, become a playground for adventure and experience-seeking tourists (see Gössling 2005; Gyimóthy and Mykletun 2004). Overall, tourists seem more environmentally aware and there is a general trend towards more educative and challenging vacations (see Urry 1995, Lindberg *et al*. 1998). This development seems to be self-reinforcing, because environmental consciousness comes into existence through education, increased media attention and the comparison of the character of the physical and built environment of different places through travelling (Urry 1995). The conclusion would be that the relationship of environmental awareness and travel is a self-reinforcing one, because a heightened environmental consciousness will lead to more travel, while more travel will in turn lead to increased environmental awareness (see Gössling 2002). Due to their attractiveness for recreation, forests play an important role in this process.

In industrialised countries, forests also have important educative, spiritual and religious roles, and they might often function as links between urbanised and industrialised societies and the natural environment. This might go along with processes of mystification and romanticisation of forests (see e.g. Knight 2000 for Japanese forests). On a more proximate level, easier access to remote destinations, better information through the internet and greater travel experience of a growing number of tourists might also explain the observed growth in nature-based tourism, particularly in the tropics (see Lindberg *et al*. 1998). It is likely that tourism and recreation in forest areas will increase in the future. This development will, in industrialised countries, be a result of the wish to recover from daily urban life, and in developing countries due to a growing interest in nature tourism by both domestic and international tourists (see Font and Tribe 2000; Ghimire 2001).

Forest tourism has a substantial economic value. On a global scale, nature tourism – i.e. tourism based on natural areas – might generate as much as 7 per cent of all international travel expenditure (Lindberg *et al*. 1998). A proportional share of the turnover from international tourism can therefore be attributed to the existence of ecosystems, often forests. In Costa Rica, for instance, more than 50 per cent of all tourists visited at least one protected area (usually forests) during their stay in 1988, and about 40 per cent stated that protected areas were important or primary reasons for choosing the country as destination (Boo 1990). Similar is true for Ecuador, with 65 per cent of all tourists stating that protected areas are an important or primary reason for their travel choice, and with 75 per cent having visited at least one protected area (Boo 1990). Broadhurst and Harrop (2000) cite the UK Day Visits Survey (SCPR 1998), which suggests that some 350 million day visits are made each year to woodlands in the UK alone. On average, day visitors spend £3.20, resulting in an estimated expenditure on woodland recreation of more than £1 billion. Direct revenues from forest-based tourism can be substantial with, for example, entrance fees of up to US$250 per individual per day being paid for visiting gorillas in Rwanda and Uganda (Wilkie and Carpenter 1999).

Not all forest values are captured in markets (see Broadhurst and Harrop 2000). Forests support ecological functions essential to humanity such as the maintenance of the global carbon cycle (Costanza *et al*. 1997; Daily 1997). Forests also have a range of other values that are outside the market, usually resulting in underestimations of their value in cost–benefit analyses and decision making, which in turn often has led to clear-cutting, particularly in the tropics (Myers *et al*. 2000). This is of importance because tourism is often giving economic value to otherwise ‘useless’ natural areas (see Gössling 1999; Hall and Higham 2000). The privately owned 21,750ha Haliburton Forest and Wildlife Reserve in Ontario, Canada, for example, earns 67 per cent of its total revenue from tourism-related activities (Sandberg and Midgley 2000). Even in industrialised countries, where access to forests is usually free of charge and generates only little value to forest owners (Font and Tribe 2000), forest tourism can generate income. For example, guesthouses, hotels and restaurants in proximity to well-known national parks and other protected areas will usually profit from tourism and, in many countries, guided tours, or experience-packages such as beaver or moose safaris, or souvenir selling industries have developed. The latter include wildlife farming for meat or the cultivation of medicinal herbs (Knight 2000). Forest tourism may also develop rather unusual forms. For example, Knight (2000) reports that some municipalities in Japan have developed ‘tourist forestry’, where tourists plant, weed, prune or thin timber plantations.

From an environmental point of view, forest tourism can be problematic because it usually concentrates on rather limited, 'attractive' areas. Problems of heavy use involve the disturbance of wildlife, trampling of vegetation, forest fires caused by camp fires or cigarette butts, erosion of soil and impacts of cars through off-road driving and emissions of different trace gases (Knight 2000).

Forests and climate change

The distribution of major forests types, such as tropical forests and boreal forests, is strongly controlled by climatic variables, in particular temperature and moisture (e.g. Prentice *et al*. 1992). Cold winters, short growing seasons and drought are environmental factors that limit the distribution of forests (Woodward 1987; Prentice *et al*. 1992). Winter temperatures are, in particular in the north, projected to increase by several degrees. Parts of the Arctic could be up to 10°C warmer by 2100 (IPCC 2001). Such changes in temperature would enhance forest productivity in many northern areas, and trees would be able to expand their ranges to the north and to higher altitudes. The observed warming of the northern hemisphere between 1982 and 1999 has already led to increased forest growth (Lucht *et al*. 2002). Furthermore, temperate trees would become more competitive in nowadays-boreal forests, but it is largely uncertain at what rate competitive replacement of different forest types may occur (Solomon 1997). Climatic change is projected to occur so fast that most forests will rather become non-adapted to the new climate than change toward a new composition (Davis and Shaw 2001). Non-adapted trees may suffer from decreased vigour and increased sensitivity to, for example, storms and pest outbreaks (e.g. Bradshaw *et al*. 2000).

Changes in rainfall patterns could also have a substantial impact on forests. Prolonged droughts can severely damage or kill large forest tracts, either directly, or indirectly through increased fire intensities (Bachelet *et al*. 2003). Dynamic Global Vegetation Models (DGVMs) have been developed to simulate large-scale climate impacts on vegetation and ecosystems (Cramer *et al*. 2001). For specific climate change scenarios, DGVMs have projected substantial forest dieback in the tropics (Cox *et al*. 2000; White *et al*. 2000; Schaphoff *et al*. 2005), as well as in south-eastern USA (Bachelet *et al*. 2003) and boreal forests (Joos *et al*. 2001). However, whether large-scale forest dieback is projected by the models depends on CO_2 emission scenarios (White *et al*. 2000) and on simulated changes in precipitation patterns (Bachelet *et al*. 2003; Schaphoff *et al*. 2005), the latter differing substantially between climate models (IPCC 2001; Bachelet *et al*. 2003; Schaphoff *et al*. 2005). Therefore, it is highly uncertain if such strong impacts will occur.

The most severe impacts are simulated to occur after 2050. However, even though general trends in climate change may be unlikely to cause large-scale forest dieback in the near future, it is uncertain to what extent forests will be disturbed by the general climatic trends in combination with more extreme weather events, including higher frequencies of windstorms (Leckenbusch and Ulbrich 2004), and prolonged drought periods (Semmler and Jacob 2004), which could promote forest fires.

Nitrogen and CO_2 fertilization

Further important aspects of global environmental change are increasing concentrations of CO_2 in the atmosphere and increased nitrogen depositions. Both CO_2 (e.g. Farquhar *et al*. 1980; Norby *et al*. 1999) and nitrogen (e.g. McGuire *et al*. 1992) are limiting resources for plants, and anthropogenic emissions are thought to have increased forest productivity (Spiecker *et al*. 1996). Nitrogen depositions have been rapidly increasing during the last 50 years (Vitousek *et al*. 1997; Holland *et al*. 1999) – in many areas, in particular in Europe, to levels at which trees suffer from negative side-effects, such as acidification, leaching of cations, and nutrient imbalances (Schulze 1989; Aber *et al*. 1995; Vitousek *et al*. 1997). In coniferous evergreen forests in Europe, nitrogen depositions have caused forest decline and increased tree mortality (Schulze 1989), and deposition rates will generally further increase in the future (Galloway 2001).

In the case of CO_2, concentrations of 580 to 970 parts per million (ppm) by year 2100 (IPCC 2001) could lead to substantial fertilisation effects (Cramer *et al*. 2001; Long *et al*. 2004). Over the time span of a couple of years, elevating atmospheric CO_2 by 200ppm has been documented to increase productivity of young trees by about 25 per cent (e.g. Norby *et al*. 1999; Hamilton *et al*. 2002; Nowak *et al*. 2004). Elevated CO_2 could have particularly beneficial effects in dry areas, because many plants respond to elevated CO_2 by decreased leaf conductance, which decreases water losses through transpiration (Drake *et al*. 1997; Long *et al*. 2004). However, it is highly uncertain to what extent other resources, such as nitrogen, phosphorus and cations will constrain CO_2 fertilisation effects (Finzi *et al*. 2002; Hungate *et al*. 2003). Likewise, it is not known how mature forests, where, for example, competition for light can strongly limit growth, will respond to elevated CO_2 (Norby *et al*. 1999).

Land-use changes

Between 20 and 30 per cent of natural forests have been replaced by anthropogenic land-use types, such as agriculture and pastures, and forest losses have been most severe in temperate and warm non-tropical forests (Klein Goldewijk 2001). Today, northern and mid-latitude forests are in a rather stable condition (Dixon *et al*. 1994). In Europe, the total forested area is projected to increase because of abandonment of agricultural areas (Kankaanpäa and Carter 2004), but tropical forest are under serious threat. Clearing of tropical humid forests eliminates about one million km^2 every five to 10 years, with burning and selective logging severely damaging several times the cleared area (Pimm and Raven 2000).

Biodiversity

Substantial extinction of species may occur in the near future because of global environmental change (Sala *et al*. 2000). Within a wide range of taxa, such as plants, birds, reptiles and butterflies, it is estimated that climate change alone will cause 15–37 per cent of the species to become committed to extinction by 2050 (Thomas *et al*. 2004; Bakkenes *et al*. 2002). The estimates vary in relation to the climate change scenario and assumptions concerning species' ability to disperse to new habitats if the climate in their old habitat is no longer suitable (Thomas *et al*. 2004). Note that these scenarios only consider the suitability of the climate in a given location; this excludes changes in available habitat that occur as a result of human land-use change, or changes in habitat quality caused by nitrogen deposition or elevated CO_2. In many areas, species diversity could become more severely affected by human land-use change and nitrogen deposition than by climate change (Sala *et al*. 2000; Thomas *et al*. 2004).

Nitrogen deposition generally decreases biodiversity by favouring the most responsive species, which often outcompete rare species confined to nutrient-poor habitats (Mooney *et al*. 1999, Sala *et al*. 2000). In the Netherlands, for example, which has the highest nitrogen deposition rates in the world, nitrogen deposition causes the conversion of heathlands to species-poor grasslands and forests (Aerts and Berendse 1988).

Elevated atmospheric CO_2 will also strongly affect biodiversity (Sala *et al*. 2000). Some species will respond more strongly to elevated CO_2 than others, which will affect the competitive balance between species currently coexisting in ecosystems (Mooney *et al*. 1999). As elevated CO_2 changes the chemical composition of produced biomass, which is consumed at higher trophic levels, not only primary producers but the whole food-web will be affected (e.g. Percy *et al*. 2002). Nevertheless, predicting the outcome of these effects on species composition in ecosystems remains difficult (Mooney *et al*. 1999; Poorter and Navas 2003). Because current CO_2 concentrations never have been exceeded during the past 26 million years (Long *et al*. 2004) – the period during which current plant life evolved – no past analogue exists for future conditions and its consequences for ecosystem composition and functioning. In general, however, rare habitat specialists are likely to suffer more from global change than widespread generalists (Warren *et al*. 2001; Travis 2003), and it is usually the former, often endemic species, which are more important for tourism.

Conclusion

The chapter has outlined the importance of forest ecosystems for tourism and recreation. It is clear that forests are likely to see substantial changes in their extension, structure and species composition. This might in particular be true for the northern latitudes, where the largest temperature increases are projected. Forest growth will probably be enhanced in many areas in the north, while elevated CO_2 could have particularly beneficial effects on forest growth in dry areas. However, climate change will occur so fast that many forests will not be adapted to the new climate, and during the second part of the century this could cause large-scale forest dieback. Furthermore, forests will generally be more likely to suffer from extreme climate events and, in most areas, forests will host a smaller number of species.

Mid-latitude forests are most important in terms of volume, because they provide the scenery for recreation in large parts of Europe, North America, Australia, New Zealand and Japan. Access to forest ecosystems is free of charge in industrialised countries (e.g. Broadhurst and Harrop 2000) and some nations, such as Sweden, even explicitly grant a Right of Public Access (Bostedt and Mattsson 1995). The economic consequences of losing species and forest landscapes might thus rather be indirect in these countries, including forgone opportunities for recreation and tourism. However, indirect tourism-related economic losses could be substantial because, for example, Switzerland would lose much of its attractiveness without its forest landscapes. Similar is true for Sweden, where the loss of charismatic species such as moose could be of great importance. Forest loss will also have cultural and societal consequences. This is because knowledge about ecosystems, production processes and the physical environment are considered to be central to sustainable development (Borgström-Hansson and Wagernagel 1999), but are increasingly lost in industrialised societies. Because forests are popular for walks, nature observation and outdoor activities, including extractive activities such as picking mushrooms or berries, hunting or fishing, forest-related activities might often be the last 'authentic' links that people in industrialised countries have to the natural environment. Forests thus have important educative, and even spiritual and religious functions (see e.g. Knight 2000, for Japanese forests). Hence, reduced access to forest ecosystems might affect the perception of and knowledge of the environment in industrialised societies. In this context it is worth mentioning that forest protected areas in many western European countries have the explicit task of mediating nature-related knowledge, compensating for the loss of 'traditional' knowledge.

In the tropics, forest national parks and nature reserves are often essential sources of income (see Langholz 1996; Gössling 1999) and their revenue-generating properties are one of the strongest arguments for their conservation. Should tourism to these areas decline, important income might be lost. Note, however, that this relationship has two sides, because tourism itself is an important contributor to climate change (Gössling *et al*. 2005). Loss of revenue from protected areas might become even more important in areas where a substantial part of local livelihoods depends on forest products such as meat, timber or herbs, which might also decline. Obviously, the loss of forests will have severe consequences for people in the tropics, with some 200–300 million people being directly dependent on these ecosystems for their livelihoods (Myers *et al*. 2000).

In conclusion, global change will considerably alter forest structure, functioning and biodiversity, including the possibility of large-scale forest damage or dieback, but it is currently not possible to predict how forest-based tourism in particular will be affected. Scientists can only provide scenarios of global change impacts, i.e. a wide range of possible developments. The future use of forests for tourism will also depend on the tourists' aesthetic perception of landscapes and forest types, their perception of damage caused by weather extremes, the loss of charismatic species and, potentially, their risk perception if disease-carrying vectors become more abundant.

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6

Environmental Change, Coastal and Marine Environments, and Tourism

Stephen J. Craig-Smith, Richard Tapper and Xavier Font

INTRODUCTION

Since the very beginnings of tourism as a significant human activity the coastal environment has been a major drawcard (Feifer 1986). The marine environment has engendered a sense of wonderment, awe, reverence and fear since humankind evolved, and much of that early mystique has remained to the present. The coastal environment has been an essential element in tourism since Roman times (Ostia outside Rome was one of the earliest coastal resorts) and the coast is as important today as it has been at any time in its history. Demands and expectations may have changed but the coast has retained its human fascination.

Early demand for coasts, islands and reefs from traditional tourists has focused on areas displaying specific geo-environmental characteristics. Traditional tourists (taken here to be mass tourists with demand characteristics commonly displayed over the past 100–200 years) have a high propensity for passive pursuits generally summed up as sun, sea, sand and sex, so the areas and types of coastline developed for tourism activities displayed remarkably uniform characteristics in most parts of the world. The presence of a sandy beach, relatively calm wave conditions for safe bathing, a relatively pollution-free environment and a relatively warm summer climate were important considerations. It is no coincidence to find the early bathing resorts in Europe, many parts of North America, Australia and even in parts of Southern Africa and South America displaying most of these characteristics. With the advent of cheap air travel the geographical spread of demand for the world's coastlines expanded but for many years the type of coastline in tourist demand displayed very similar characteristics. People travelled further afield but expected much the same product on arrival. The mass resorts in Spain, on the north coast of Africa, in many parts of the Caribbean and even in South East Asia have only superficial differences from the traditional resorts of Northern Europe or North America. Accessibility – albeit further distant geographically – good climate, safe bathing conditions, a reasonably clean environment and supportive tourism infrastructure are as significant in these newer resorts as they were with the traditional ones.

More recently tourism has begun to change and post-modern tourists are demanding different characteristics from the coastal environment. Post-modern tourism is still not as common as traditional tourism but it is growing in importance. While it is important to remember that even post-modern tourists have not totally neglected the traditional resorts, they are increasingly seeking new experiences and as a consequence seeking out new coastal, island and reef areas to exploit. The post-modern tourist is generally less interested in passive pursuits and is more likely to be engaged in more active and or educational activities such as surfing, diving, sailing, walking, bird spotting, nature viewing or general exploring. Some, if not all of this wider portfolio of vacation activities is less dependent on a warm climate (most Antarctic visitation is currently confined to the coastal edge) or safe bathing conditions, so not only are more sections of the world's coastlines coming under coastal tourism development but a greater range of coastal environments are being affected.

The coastline is a particularly unique element of the landscape being the edge of the land where it meets the marine environment. It is exceedingly universal and is found in all countries which border seas or oceans and is even present in modified form on the edge of large inland water bodies such as the Great Lakes. However, the coastline in most places is relatively narrow, comprising that band of the Earth where the marine and terrestrial environments meet. This often results in high energy interaction and mega-episodic effects. Furthermore, this narrowness means that much of the world's coastline is ecologically vulnerable because there is limited scope for migration – there may be room to move laterally along the coast but there is very limited scope for plant and animal life to go either far inland or far offshore. This limited scope for eco-migration displays similar characteristics to the issues in mountain areas described in Chapter 3.

Of course, it is not just tourism which is attracted to coastlines. For a wide variety of reasons the world's coastlines are a magnet for a miscellany of human activities from power generation (the presence of large quantities of water for cooling purposes), agriculture (the presence of flat and often good quality land enjoying the ameliorating effects of the oceans on climatic extremes), industry (convenience of export and transshipment of goods and raw materials), urbanisation (attraction of the coast for lifestyle, moderated climate and employment) and increasingly in recent times retirement development with its associated support structure and recreational activities (Timmerman and White 1997). This multiple and competing use of the coastline is significant for environmental change because much of the environmental change is driven directly be these multiple coastal activities. Add to these locally generated changes more general global change affecting the whole of the planet and it becomes immediately obvious that many coastlines are extremely vulnerable (Kuijper 2003). For tourism to survive and prosper in such locations, long-term environmental monitoring and systematic data collection on environment change is not just desirable, it is essential.

To cover all the coastlines of the world and examine all the permutations and combinations of environmental change associated with them is completely beyond the scope of one chapter so set out below is a framework designed to be representative of the more significant and frequently occurring issues. It is not intended to be totally comprehensive or encyclopaedic in nature.

Environmental change

At any one time, a natural system adapts to the environmental processes operating at that time and coastlines are no exception to this rule (Hansom 2001). If, for whatever reason, the current environmental processes change so also will the natural environment; this is the natural order of things which has operated for the past 4500 million years. Environmental change is brought about by many causes and this chapter attempts to examine many of them, but perhaps the most significant change at present is the rise in world atmospheric temperature. For this reason, global climate change is accorded first priority and other aspects of environmental change are examined later.

In the geological past world climatic conditions have been very different from those of today, at times being much warmer than now and at other times much colder. Given the significant climate variations observed within the geological column one might wonder why there is so much concern about current climate change. There are two reasons why current change is viewed with such alarm. First, the rate of current change is occurring at what we believe is a much faster pace than at any previous time in history. Second, current climate change is caused by human and not natural causes. Furthermore, because of the nature of human interference with the chemical composition of the atmosphere, the resultant changes are global and not regional in scale – unlike most other human activity effects such as sand dredging or uncontrolled pollution discharge which may have significant local impact but rarely have global implications.

Because the nature and causes of global climatic change have been discussed elsewhere in this book, this chapter focuses only on the likely effects such warming may have on the coastal environments of the world and what influence those likely effects will have on coastlines and their subsequent human use. Changes due to global climate change are discussed first and other environmental changes of a more local nature are discussed second.

Sea-level rise

Sea levels have been rising for the last 10,000 years, ever since the last glacial ice sheets of the world started to melt, but the current rapid temperature rise is having an accelerating affect. Sea-level rise is due to two different but related factors. As the world's ice sheets melt, thousands of cubic kilometres of water are returned to the oceans thereby increasing their volume which inevitably leads to sea-level rise. But, in addition, as the existing water in the oceans warms up, so it expands and further compounds the problem. Worldwide, the oceans are rising at around 1–22mm per year but this could accelerate in the future. For a variety of geographic factors sea-level rise is not uniform and some parts of the world have witnessed greater rises than others (Doornkamp 1998). The National Tidal Facility at Flinders University in South Australia, for instance, has reported sea level rises in the South Pacific in the order of 25mm per year – over 10 times the global trend. Satellite data show sea-level rises in the region between Papua New Guinea and

Fiji to be nearer 20–30mm per year. Globally, if current trends continue sea level is predicted to rise by another 5 to 12 centimetres some time around 2020.

On upland coasts sea level rise may not be too serious but in many parts of the world tourism development has occurred on lowland coasts as near the ocean as possible. Many of the coral atoll islands of the Pacific, for instance, with average land levels only a matter of one or two metres above high tide level, are threatened with total extinction (Burns 2000). To maintain some existing coastal resorts in the face of rising sea levels may prove prohibitively expensive and require protective measures unacceptable on environmental grounds.

Changing levels of cloudiness

Although not in the same category as sea-level rise, changing levels of cloudiness can be significant for coastal tourism. Because global warming is affecting pressure and wind patterns, the world's rainfall pattern and cloud cover distribution are also changing. Levels of rainfall and daytime temperatures are also intimately linked with levels of cloud cover. The impact of the level of cloud cover will depend on the current state of cloud cover in the area being considered. In cool and cold regions of the world increased cloud cover could act as a deterrent to future tourism because cloud cover reduces the daytime temperatures and creates the impression of gloominess which most traditional tourists dislike (Viner and Agnew 2000; Wall 1992). In hot regions of the world, however, increased cloud may actually be better. Australia for instance has one of the highest incidences of skin melanoma in the world and increased cloudiness in Northern Australia could be a good thing. Increased cloud cover could have an ameliorating affect on maximum daytime temperatures and lessen the effect of increased global temperatures.

Less cloud cover will also have varying effects on tourism. Less cloud cover in cooler climates could be a good thing with much of northern Europe and Canada standing to benefit greatly from such a phenomenon. Southern European coastal destinations are popular with visitors especially from northern Europe. Giles and Perry (1998) suggest that a temperature increase of only 1 or 2°C might remove the need for northern Europeans to travel south for good weather coastal holidays. In warm and hot climates, however, less cover could be a bad thing by increasing daytime temperatures to levels no longer comfortable for the majority of tourists. Increased temperatures on parts of the Great Barrier Reef off northern Australia and on reefs off the Maldives have led to a killing off of some corals which results in what is called coral bleaching. The colour in coral reefs is caused by the presence of small organisms and once these die off the coral reefs lose their colour (Agnew and Viner 2001).

In areas which currently experience a wet regime, such as the west coast of Scotland or the west coast of the South Island of New Zealand, less rain could be a good thing for tourism where the current number of wet days acts as a deterrent to tourism activity. In areas currently deficient in rainfall, however, such as parts of Australia and the Pacific Islands, lower levels of rainfall in the future could be nothing less than catastrophic. In these areas, current water shortages are leading to unsustainable levels of water use for irrigation purposes (Fiji, for instance) and a further lowering of the water table would have very serious consequences, not just for tourism but for entire island communities in the Caribbean and Pacific. The benefits of a heavier rainfall regime will also depend on geographical location. Heavier rainfall can lead to an increased incidence of coastal flooding which is a bad thing, but it could lead to less fossil water use and water importation dependence in drier areas. Probably the only tourism activity which would directly benefit from a greater incidence of rain would be recreational fishing.

Increasing storminess

Temperature warming is contributing to a world increase in cyclones, tropical lows and storms in general. It has been suggested that tropical cyclones could increase in intensity by between 10 and 20 per cent with a doubling of CO_2 in the Earth's atmosphere (Ker 1999). During the second half of the twentieth century the average number of cyclones in the southern Pacific has been seven per year but this is likely to increase to eight in the early decades of this century. Such storms not only bring with them strong destructive winds but the winds raise sea level by pushing surface seawater in front of them and contribute to widespread flooding as well as structural damage. For many coastal tourism structures and facilities the threat of storms is greater than the threat of rising sea level but the two go hand in hand.

The implications of increased storminess for coastal tourism are many and serious. Storms are not just an inconvenience, they can be life threatening. Storms can disrupt transport communications, cause widespread coastal flooding and coastal erosion, and cause considerable structural damage. It is a well-known meteorological phenomenon that coastal cyclones and storms are worst where they cross the coast and that they tend to die out once they cross a land mass. Protection of beaches and coastal infrastructure against storms is technically possible but the cost may well render the project uneconomic and, as with sea-level rise, protection works may prove unsightly and environmentally unacceptable.

Changing glacial activity

In recent years there has been an increasing interest in actively glacial coastlines. This reflects changing demands of tourists in coastal areas as outlined at the beginning of this chapter. With the advent of more and larger coastal cruise ships, active glacial coasts have come under increasing tourist interest. The coasts of northern Canada, Alaska, southern Chile and Antarctica itself have seen a dramatic rise in tourist activity. Further and faster glacial melt will result in less and less of this environment being available for the tourist gaze. While non-active glacial coasts, such as those on Scotland's western seaboard, undoubtedly attract tourists the active glacial coasts have no close substitute. A further reduction in active glacial coastlines will result in cruise ships having to travel closer to the polar regions to view the best glacial scenery. Because most cruises originate in the warmer regions of the world, greater distances will have to be travelled and, therefore, increases in cost and time will have to be expended to see much of this type of environment.

Management of impacts in coastal areas

So far this chapter has concentrated on the global aspects of environmental change. Given the significance of global climate change this is not surprising, but it would be wrong to assume that the only environmental change is as a result of global warming, especially where coasts are concerned. While other changes are more local in character they can nevertheless be significant in certain areas. With the extensive tourism that coastal areas support, and the general trend for expansion of tourism, it is important that sustainability factors are fully incorporated into tourism planning, development and management at all levels, by both the public and private sectors (Tol *et al*.1998; Kuijper 2003). In particular, the public sector has a key role providing and enforcing planning systems for reviewing and approving proposed developments, and for preparation of land development plans that take into account sustainability issues and which incorporate an integrated approach to tourism and coastal and marine management. A range of tools can be used to help implement sustainability within frameworks based on the above factors, which are summarised in Table 6.1. The selection of the appropriate tools to use in any circumstance will depend on the nature and severity of the issues to be addressed.

Information on the main sources of coastal and marine pollution for states with Caribbean coastlines (Hoagland *et al*. 1995) identifies sewage (28 states), oil (22) and mining and industry (20). Construction erosion (9), solid wastes (6) and fertilisers and pesticides (6) also had significant impacts in some states. Tourism is affected by environmental impacts and pollution from other sectors, as well as causing impacts itself. Generally, adverse impacts from the tourism sector tend to be limited to zones just a few kilometres from where tourism takes place, and the evidence available from the mid-1990s confirms that the environmental effects of tourism activities in coastal areas occurred within national boundaries and territorial

Table 6.1 Regulatory instruments

Regulations	*Economic approaches*	*Soft tools*
Laws and regulation Special status designation	Taxes, subsidies and grants Tradable rights and permits Deposit-refund schemes Product and service charges	Community programmes, national and local networks Tourism ecolabelling Environmental management systems Certification/award schemes Guidelines, treaties and agreements Citizenship and education

waters (UNEP 1994, 1997). In the study for UNEP's Caribbean Environmental Programme (CEP), the major categories of effects from tourism were identified as:

- change in sediment loads
- displacement of traditional uses and users
- groundwater depletion and contamination
- physical changes and habitat damage
- solid waste disposal
- toxic chemicals and nutrification from surface runoff
- visual impacts.

Although tourism impacts are generally localised, they are hugely significant both economically – because they occur in the areas which are of high value for tourism – and environmentally – because many of the features that attract tourism are also of major importance for environmental and conservation reasons. Besides wider environmental costs, adverse impacts caused by tourism undermine both public and private investments from local to national levels. Such adverse impacts from tourism can be avoided through proper and effective planning and development.

A further consideration in small islands is that any impacts have proportionately greater effects than in larger land and coastal regions, simply due to their physical features. For example, a coastal development which results in changes to coastal erosion and sediment deposition that extend over a few kilometres may have limited effects if present on a large landmass, but in a small island may affect a substantial part of the island and its coastline, with consequent economic and environmental losses. Four sources of local impacts are considered in more detail. Each sub-section includes a table summarising the main impacts, along with examples of management tools, and regulatory frameworks and options that are available and in use for addressing such impacts.

- Coastal erosion
- Habitat degradation
- Pollution
- Waste handling and management.

Coastal erosion

The coast is a dynamic environment, with erosion as well as build up of material along coasts and shorelines part of a natural cycle of change. Examples of activities sometimes associated with tourism that can affect the rate, pattern and extent of these physical processes are coastal development, beach protection schemes, schemes for replacement of sand from beaches where it is being otherwise eroded, and sand extraction from beaches.

In some cases protection and stabilisation may be required as a consequence of initial inappropriate site choices for coastal infrastructure or properties, or a failure to understand the environmental or physical impacts associated with certain types of coastal features or protection measures. In other cases the structures themselves may be the cause of the problem when these are located within the area of influence of coastal processes. Structures to consider that are mostly associated with tourism are likely to be hotel developments and recreational facilities for marine activities that are built on the shoreline or extend across the intertidal zone. The effects of such structures on coastal processes may be apparent in the immediate vicinity or many kilometres distant. Making planning decisions about such structures within a broader Integrated Coastal Management programme, such as is the case of Barbados, is much more likely to result in sustainable development.

Reefs and mangroves are two marine habitats that provide natural protection against coastal erosion by reducing the impact of wave action on the shore. Mangroves act to stabilise the coastline and aid the accumulation of sediment. Coral reefs act as a natural breakwater, reducing the force of waves that reach the shoreline. Natural damage to these structures, for example, by hurricanes, or damage caused by human activities such as the blasting of channels through reefs or clearing mangroves can affect coastal processes and make coastlines more vulnerable to changes in beach profiles.

Where new structures are required they must be carefully designed to limit any adverse environmental impact, regularly monitored to ensure subsequent achievement of intended function, maintained when integrity or function is impaired and replaced (or removed) when changed circumstances or conditions justify this. For example, beach sand removal is another key impact along coastal areas. The development of resorts and marinas along the coast as a result of tourism development can bring about significant local environmental change. The beach is the natural defence of the land against the power of the sea. In periods of storms, wave energy is expended along the shore line by removing beach sediment offshore. In intervening periods of calm weather that sediment is returned to the beach. This onshore–offshore movement of beach sediment is a natural process and in the long run is by far the most cost efficient. All too frequently, however, beach material is removed for building purposes on the grounds that it will naturally build up again once removal has taken place. Regrettably this is not always the case and the beaches simply disappear. This problem is compounded when coastal development is protected by the construction of sea walls which might protect the area landward of the sea wall for a short time but in the long run simply starves the beach system of one of its natural sources of sand. Marina construction and channel dredging also change the coastal environment by impeding the natural long shore movement of beach sand (Table 6.2).

Habitat degradation

Tourism-related activities may be a primary or a contributory cause of the degradation of coastal and marine habitats, including coral reefs, seagrass beds and mangroves. Degradation of all these habitats has the potential to affect tourism, especially for visitors who choose destinations for their environmental quality and interest. It should however be noted that a wide range of activities cause these

Table 6.2 Coastal erosion

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Beach erosion	Zoning to avoid development in vulnerable areas Modelling studies to improve understanding Monitoring programmes to detect changes	National development plans Environmental Impact Assessment
Sediment budget changes (i.e. changes in the balance between build up and erosion of sediments on a beach/coastline) and beach/dune mobility	Potential effects of coastal works and other activities assessed at a scale appropriate to coastal processes (i.e. not just local)	Regional planning
Loss of tourism infrastructure	Long-term planning horizons e.g. 50 years Set-back limits	Strategic Environmental Assessment
Beach and water quality and safety of beach users	Monitoring changes in beach conditions 'Blue Flag' initiative	

types of degradation, only some of which are associated with tourism. They include physical impacts from coastal development, marine and shore-based activities, and water quality issues such as the discharge of effluents. Many of the impacts are associated with other activities (e.g. fisheries, dredging, effluent discharges, coastal development) and management options are tabulated in the other sections.

One of the most obvious signs of the degradation of coral reefs is physical damage, where sections of coral are broken off or abraded, for example, by anchoring on reefs. Smothering of reef areas by algae, and areas of diseased and dead coral are also very obvious signs of degradation although the causes are less visible. They include siltation – where fine particles of sediment suspended in the water are deposited onto reefs and their living corals – or nutrient enrichment – for example, from disposal of sewage at sea, or from agricultural fertilisers that are washed by rainfall and irrigation, off the land and into rivers and coastal waters – which can lead to a more gradual deterioration of the reef structure and associated groups of plants and animals. Additional impacts on the associated communities range from activities such as the collection of reef fish for the aquarium trade through to commercial fisheries. These effects need to be viewed in combination with natural damage, such as that caused by storms, and regional or global effects such as elevated sea temperatures linked to global warming and El Niño conditions.

Seagrass beds and mangroves are highly productive areas acting as nursery grounds and stabilising sediments on the shoreline and sea bottom. In the case of mangroves, deliberate clearance has taken place in many locations, whereas damage to seagrass is more likely to be inadvertent and the indirect result of other activities. In both cases habitats support considerable biodiversity, and damage to them, sometimes as a result of tourism activities, can reduce the overall attractiveness of areas to tourists, as well as causing a loss of environmental services and impacting on fisheries.

Poor water quality is one of the factors that has resulted in the degradation of saline lagoons, estuaries and inlets where water movement and exchange is limited. Pollution can accumulate in the sediments and in conditions of limited water exchange the concentration of pollution may increase. Estuaries can also focus pollution from the watershed.

Further impacts in coastal areas are the result of deforestation. Human removal of large tracts of natural vegetation for agriculture and other economic ventures is having a significant effect on many segments of the world's coastlines. Large scale vegetation removal renders large tracts of the Earth's surface vulnerable to rainfall runoff erosion. Quite apart from the environmental devastation such activity causes inland, the resultant increased sediment load brought down by the rivers to the coastal environment can have catastrophic consequences on the coastal ecology. Suspended sediments in coastal waters make them less attractive to tourists and can kill off much of the existing coastal biomass.

Similar to deforestation, there are impacts arising from coastal vegetation clearance. Coastal development, especially on lowland and tropical coasts, is renowned for its cavalier attitudes to coastal vegetation removal. The desire for all tourists to be able to see the ocean leads developers to remove coastal vegetation, especially mangroves which tend to hug the shoreline and impede sea views. Mangroves are an ideal fish breeding environment and, once removed, entire local fish stocks are affected. Quite apart form this, mangrove removal can lead to local beach erosion and increased mud sediment load being released to the sea (Table 6.3).

Pollution

Sewage, grey water discharges and litter are those most likely forms of pollution to be associated with tourism activity (see *Waste handling and management*). Other types of pollution, while not normally arising from tourism activities, can deter visitors because of aesthetic problems or worries about health and contamination of food and water quality. In each case there are effective ways to deal with the waste causing such pollution to avoid damage to wildlife and the marine environment.

There are many different forms of oil with varying associated risk of pollution and difficulties with clean up. Lighter types of oil (petrol, marine diesel) evaporate rapidly at sea and are quick to degrade, but can cause damage in confined situations such as lagoons and inlets or if they become trapped in sediments. The action of waves can produce an oil/water emulsion which is difficult to clear up while heavier types of oil may eventually form tar balls which sink to the seabed or get washed up on beaches.

Table 6.3 Habitat degradation

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Habitat damage and loss through infrastructure development, construction, upgrade and maintenance (e.g. ports)	Building contracts	Environmental Impact Assessment
Impacts of cruise operation	Internal operating standards	Environmental Management Systems Regulatory operating standards
Impacts from marine recreation	Permanent buoys for anchoring in sensitive areas	Zoning

Pesticides in watercourses and coastal waters are most likely to come from diffuse sources on land, which are then carried to the coast in runoff and down watercourses. They include insecticides, herbicides, fungicides and rodenticides. The best known is DDT which is toxic in its own right but is also only broken down slowly, and then only to other persistent derivatives such as DDE which is also toxic to a variety of organisms. Pesticide pollution linked to tourism is mostly associated with management of the grounds of hotels and sports facilities – for example, golf courses.

Use of fertilisers in agriculture and grounds management can also give rise to water pollution by increasing the concentration of nutrients – particularly of nitrates and phosphates – in the water from runoff and leaching of fertilisers. Such increases in nutrient content adversely affect water quality both directly, and by stimulating the growth of algae leading to 'algal blooms'. Algal blooms are often highly damaging to aquatic ecosystems, and reduce water quality so that it is not suitable for swimming: in some cases, they may also excrete toxins. Toxic substances such as heavy metals (for example, mercury, cadmium, lead and copper) may be present in industrial effluents and can be accumulated to harmful levels in marine organisms, as can organic pollutants such as PCBs which are persistent and fat soluble (Table 6.4).

Desalination plants may be an issue in some areas with the discharges depending on the type of plant. The resulting effluent may have an increased salinity – which will also increase the acidity of the water – temperature and organic content, compared to intake water. There is also the possibility of increased concentrations of copper and other metals in the effluent from the use of descaling and antifoam agents. Resulting effects on plants and animals living on the sea floor and on reefs in the vicinity of these inputs may be localised, limited to species that are unable or less able to move from the affected areas, and apparent on a variety of time scales.

Table 6.4 Pollution

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Poor water quality	Discharge consents with conditions Treatment plants Catchment management plans	Regulation of discharges Red lists of substances not to be discharged Water quality standards Environmental Management Systems
Acute effects of pollution from accidental spillages and releases	Oil spill contingency plans	National procedures
Chronic effects of pollution from general use of pollution-causing materials	Monitoring programmes Phase-out programmes for specific pollutants Fertiliser management programmes	Red lists
Aesthetic damage	Beach cleaning programmes	

Waste handling and management

Sewage effluent that is discharged into coastal waters may have been subject to various levels or treatment (for example, settlement, filtration, aeration, UV treatment) or be discharged as raw sewage. The inorganic nutrients in sewage, such as nitrogen and phosphorus, increase the nutrient load to inshore waters with consequences such as depletion of oxygen and algal blooms. This is particularly serious in nutrient-poor reef environments. The release of pathogenic micro-organisms in the sewage can be a public health hazard to bathers or through contamination of local fisheries.

Solid waste such as sewage sludge – from treatment plants – and channel dredgings are another potential source of pollution with detrimental effects caused by smothering of the sea floor with sediments, creating anaerobic conditions (where there is no oxygen present in the water), altering the nature of the seabed and increasing the murkiness of water during disposal and possibly for a time afterwards both at and around any disposal site. Litter is another form of solid waste and may be seaborne (e.g. from vessels, lost fishing gear and other marine debris), disposed on the shoreline, or brought down by streams or blown in from nearby landfill sites. Apart from being unsightly, marine litter can kill seabirds and turtles by entanglement and ingestion of plastics.

Managing tourism activities

The impacts of tourism on marine coastal areas are the result of myriad agents for change at the macro level. However, impacts happen at the micro level and it is

Table 6.5 Water handling management

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Poor water quality	Discharge consents with conditions Treatment plants Waste disposal systems Grey water and solid waste recycling	Regulation of discharges Water quality standards Environmental Management Systems
High volumes of waste for disposal	Waste separation, reuse and recycling	Regulations for waste management Charges for solid waste disposal Incentives for composting and waste recycling Development of waste recycling infrastructure
Chronic effects from waste materials	Monitoring programmes	Restricting or banning use of specified chemicals and other toxic materials
Aesthetic damage from waste materials	Beach cleaning programmes	

only the accumulation of these micro impacts that creates the macro conditions. The next section of this chapter reviews the impacts and management tools available for public and private sectors in and around coastal areas to contribute to a better quality environment. Tourism activities will not be managed to tackle climate change alone, but a range of impacts, mainly first concentrating on those that have short-term, local impacts that can be linked to specific forms of production and consumption. For this reason the impacts and management choices reviewed here take a firm-based, not climate change specific approach. Five types of tourism activities are reviewed: cruise ships, local sourcing of produce, marine-based activities, recreational areas and commercial fishing.

Cruise ships

Cruise ships make an important contribution to the tourist industry, for example, in the Caribbean and South Pacific The key issues to consider are those associated with the supporting land-based infrastructure, and the operation of the vessels at sea. On land, the location, facilities, and operation of the port can have both direct and indirect impacts on coastal and marine habitats. These cover a spectrum from the total loss of habitats during port construction (for example, mangrove, seagrass, dunes) to more gradual changes as a result of chronic pollution from day-to-day operations (for example, through discharge of oil/fuel wastes, anti-fouling paints). The implications go beyond the loss of biodiversity *per se* because habitats such as these may be spawning grounds or nursery areas for fish, or make a valuable contribution to wildlife tourism and the associated plants that grow on sediments in coastal waters, and keep them in place. Without these plants sediments may be moved around by water currents, damaging beaches and reefs, and silting up channels used by boats. The effects of pollution may be aesthetic, with oil and tar balls washed up on nearby beaches, or have a detrimental effect on local fisheries, for example, by tainting produce taken for human consumption.

Because most of the ports used by cruise ships are well established, it is the upgrading and maintenance of the port facilities that should probably be given most attention at the present time. The trend towards increasing vessel size, for example, has implications for the need for capital and maintenance dredging to retain access to berths. This will not only have a direct impact on the marine communities in the channels, but also further afield, as sediment plumes that form during dredging operations make the water murky, partially blocking out light, and smother plants and animals that live on the sea floor, damaging or destroying them. In addition, the disposal of sediments dredged from channels to keep them open for boats and shipping can have negative effects on bottom-dwelling plants and animals. These effects can also be increased if the sediments are contaminated with pollutants. The location of anchorages outside the port area will also need to be chosen with care as will the likely effect on any extension of jetties and breakwaters (Table 6.6). These issues are discussed further in the section on habitat degradation.

Another set of issues is associated with the passage of cruise ships within and beyond the national territorial waters and Exclusive Economic Zones. They include the need for responsible disposal of waste (for example, sewage, garbage) which can affect water quality as well as having harmful effects on wildlife, such as the entanglement of turtles and seabirds, and care over the exchange of ballast water because of the possible detrimental effects on native species should alien species carried in ballast water become established. The International Convention for the Prevention of Pollution from Ships (MARPOL) includes the regulation of the disposal of wastes from ships. For example, the wider Caribbean, including the Gulf of Mexico, is a Special Area under Annex V of MARPOL (Regulations for the prevention of pollution by garbage). This prohibits the dumping and disposal of any wastes overboard in the region except food waste, which should be macerated and discharged as far as practicable from land but in any case not less than three nautical miles from land. Where solid and liquid wastes are disposed of in shore reception facilities, the problem is simply transferred onshore where incineration and burial at landfill sites are some of the options that may be used. However, such options are impractical or damaging on small islands where space for such facilities is very limited. Shipping accidents, with the potential for some associated marine pollution, are also always a risk.

Local sourcing of produce from coastal and marine ecosystems

Enjoying the local produce is part of the tourist experience but this can put significant additional pressure on marine resources that are already marketed locally, or

Table 6.6 Cruise ships

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Port facilities, dredging	Zoning through land use planning	National development plans Environmental Management Systems for Ports Environmental Impact Assessment
Accidental discharges	Ships routing measures e.g. VTSS, use of pilots	Oil spill contingency planning SOLAS and MARPOL convention
Deliberate discharges	Policing, waste reception facilities	MARPOL convention
Introduction of alien species in ballast water	Tanking facilities, offshore exchange	MARPOL convention
Contamination from anti-fouling paint	Containment of runoff around dry docks	Int. Convention on the Control of Harmful Anti-fouling Systems on Ships

create new markets on a scale that cannot be met by sustainable fisheries. Reef fish and crustaceans, such as groupers, snappers and lobsters, are often popular and where there is a limited local supply, or considerable demand, there is a danger of overfishing. This will have the direct effect of depletion of the target species as well as knock-on effects on the structure of the marine communities from which they have been taken.

Another local sourcing issue of potential concern is the sale and collection of marine curios. Turtle shells, coral, seafans and the colourful shells of marine molluscs are some of the marine souvenirs bought or collected by visitors. Some of these may be threatened or endangered species – and therefore subject to international controls on the collection, sale and trade – while the removal of others, although not prohibited, may lead to a more gradual depletion and change in the structure of marine communities (Table 6.7).

Marine-based activities

Marine-based activities are part of the tourist experience at many coastal destinations. A number of issues need to be considered in relation to how and where these activities are carried out. Diving and snorkelling are very popular and in many places the conditions are ideal for beginners. This creates potential problems because it is the inexperienced groups that are most likely to cause damage to reefs by trampling on corals, holding on to reef structures and stirring up sediment. Large numbers of experienced divers and snorkellers repeatedly using the same

Table 6.7 Local sourcing of products

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Collection/sale of marine curios	Educational material for tourists Awareness/training in relation to collection of permitted curios Alternative income sources for traders	Nationally protected species lists CITES Convention on Biological Diversity
Depletion of reef fish	Zoning, closures, quotas, size limits Local management of fisheries Sourcing information for restaurants and hotels	National fisheries regulations Regional fisheries management

area may also have such an effect. Feeding of fish during snorkelling and diving is permitted and even encouraged in some places, however this can affect fish behaviour by drawing fish away from other reefs and making some species more competitive and aggressive. The ecological balance of species on the reef may also be altered because of a secondary effect on the fish and invertebrates that form the normal diet of these species. Fish health may also be affected by feeding with inappropriate or contaminated food.

Spearfishing is also an issue because of the ability of those carrying out such activity to target particular species and preferentially take larger fish from reefs. This will not only deplete the area of such fish but also affect the balance of the reef communities and the behaviour of fish such as groupers, which are often the target of such activity, and which subsequently become much more cautious in the presence of divers and snorkellers.

The potential negative effects of water skiing, jet skiing and windsurfing are mainly tramping effects in launch areas and, in the case of the former two activities, noise disturbance. This can be a nuisance to nearby residents, other beach users and may disturb and displace shore-feeding birds.

In the case of recreational craft there is a potential for conflict with other users, particularly when close to the shore where swimmers, divers and other marine-based activities are taking place. Anchoring may also cause some damage, particularly in reef areas or on seagrass beds, especially if such areas used by large numbers of craft or on a regular basis, and the wake of motorised craft can lead to shoreline erosion.

Sea angling is another popular marine-based activity with both casual and competition fishing enjoyed in many coastal locations. There is growing concern about the capture of some of the large species found in open water, such as marlin and tuna, which are targeted by offshore anglers as well as commercial fishermen.

Table 6.8 Marine-based activities

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Habitat damage (reefs, seagrass beds)	Public education programmes Codes of conduct Snorkel/diver training Good site selection for training Zoning of activities	CITES Marine Protected Areas Internationally recognised diver training programmes (e.g. PADI, BSAC)
Anchor damage	Mooring buoys, notification of unsuitable anchoring areas on charts, public information, wardening	Marine management plans with associated regulations
Fish community changes	Prohibition or regulation of spearfishing and fish feeding Angling codes of practice	National/local fisheries regulations
Shoreline erosion	Speed limits	Monitoring programmes
User conflicts	Zoning schemes, wardening	Community management schemes

Depletion of these fish species has resulted in angling associations introducing codes of practice, which include no landing policies so that fish are released alive, back into the wild (Table 6.8).

Recreational areas

The coastal environment is the focus for most of the tourism in coastal areas, with extensive use of beaches as recreational areas. Recreational impacts may arise from a range of recreational activities, for example, shoreline camping, sunbeds and umbrellas, beach sports, reef and coastal trail walking, boating, water skiing and jetskis, fishing, and scuba diving. Issues to consider are the opening up of access to such areas, associated physical development on the shoreline and any effects from the presence of large numbers of people in potentially sensitive coastal and marine environments. These range from disturbance and direct habitat damage to a more gradual deterioration in the quality of the environment (Table 6.9).

Commercial fishing

The sustainable management of commercial fisheries is a difficult challenge for all maritime nations. The links between tourism and fisheries are most often a very minor consideration in any such management, but there are two areas that are

Table 6.9 Recreational areas

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Disturbance of turtle nesting areas	Seasonal restrictions on use of areas	Convention on Biological Diversity
	Development control	Land use planning regime
	Mitigation measures (e.g. beach lighting requirements)	
Habitat fragmentation and damage	Networks of protected areas	Planning policy guidance
	Wildlife corridors	
Beach cleaning	Codes of practice	

worth discussing in the current context. The first of these is the effect of unsustainable fisheries on tourism. While not as significant as any effects on the fishing industry itself, the depletion, disruption and destruction of fish stocks and damage to fish habitat will make the promotion of such areas as snorkelling and diving destinations untenable in the long run. Any associated loss of charismatic species, such as turtles and sharks, will further degrade the attraction of visiting these locations compared to destinations where it remains possible to have close encounters with such species.

Negative effects can also take place in the other direction with tourism displacing locals from traditional fishing grounds. This may be because of the physical obstacle of coastal development blocking access to traditional beach launch points, establishment of marine protected areas to attract tourists but where fishing is banned, and incompatibilities in use of the water space, for example jetskiing in areas where mobile gear fisheries are taking place. Effective resolution of these issues in a way that can enhance both fisheries and tourism is possible, as occurred in the Soufrière, St Lucia, where a participatory process ensured the success of a marine management scheme bringing benefits to both fisheries and tourism (Table 6.10).

Conclusions

The world's coastlines have been in the past, and continue at the present time to be, significant tourist attractions and while the traditional tourism demands on this environment might be changing, the coasts' overall attraction remains strong. Unlike some other forms of tourism such as urban or shopping tourism, coastal tourism relies heavily on the natural environment and any change in that environment is bound to have significant consequences for future tourism use. As has been demonstrated in the general account and in the specific case studies within this chapter, future tourism use will be affected in many ways. An increase in temperature and a decrease in rainfall may be beneficial in some coastal environments but

Table 6.10 Commercial fishing

Issues	*Examples of management tools*	*Regulatory frameworks and options*
Impacts on marine biodiversity	Fisheries regulations including gear, area and size restrictions Species specific protection measures	Fisheries management regimes (national and regional) Convention on Biological Diversity Marine protected areas
Conflicts of use	Zoning schemes Codes of conduct Voluntary agreements Community projects Participatory planning	ICZM, marine planning zones

could be catastrophic in others. An increase in sea-level rise would be of marginal significance in the upland fiord coasts of Norway or New Zealand but could be potentially lethal to low lying atoll regions of the world.

The significance for tourism is great. Some parts of the world's coasts could become more attractive to tourism and might well benefit from a rise in temperature. Coastlines in the higher latitudes may well benefit with more visitation and a longer visitor season but other places, generally in lower latitudes, could well suffer. There could well be a global shift in coastal tourism use to higher latitudes.

The other likely consequence of environment change will be engineering adaptation to existing tourism infrastructure. Stronger structures capable of withstanding higher wind speeds, artificial temperature control by the introduction of more air conditioning systems, and coastline stabilisation by means of sea wall construction are but a few of the possible engineering methods available. There are, however, many downsides to engineering solutions. Stronger structures, air conditioning and sea wall construction are all expensive solutions which may well render many existing coastal tourism operations uneconomic in the future and increased interference with the natural environment flies in the face of current tourism trends for sustainability, authenticity and local difference. Who wants to fly to Polynesia or the Caribbean to stay in a hotel similar to the ones available in London, Sydney or New York, to stay inside their air conditioned rooms and see the sea only from the top of a concrete wall? Environmental change has serious consequences indeed for coastal tourism.

There are many challenges in managing climate change, mainly arising from the fact that it is the result of many small actions taken by a myriad of agents. For this reason this chapter has reviewed a range of actions that public and private sector agents operating in marine coastal areas can take to manage their immediate environment that in turn will contribute to the short-term improvement of the local environmental quality, and that, in turn, will contribute to lessening tourism's pressure on the global environment. To facilitate these individual actions, a range of key factors can be identified that are important for an integrated approach to tourism and coastal and marine management (Table 6.11).

Table 6.11 Key factors in an integrated approach to tourism and coastal and marine management

1	Operation of good spatial planning mechanisms linked to long-term strategic planning, with inclusion of sustainability considerations as an integral part of decision making. These mechanisms should provide an overall plan of where to allow development, how much and of what kind. They would include integrated planning of tourist development balanced with other uses/developments and with the need to maintain areas free of development, so that environmental quality is maintained to attract tourists and sustain fisheries. Elements include: • co-ordination between relevant agencies and public authorities • incorporation of Environmental Impact Assessments/Strategic Environmental Assessments combined with an ecosystem-based approach to island management • open and transparent planning procedures that include full consultation with stakeholders – including inputs of local knowledge, innovation and practices in planning – for all developments, without exception • consideration of cumulative effects of development for both large and small-scale developments when taking development and planning decisions • making informed decisions on the basis of a) good baseline information on natural resources/features and any trends in these, b) international obligations, and c) understanding of local/indigenous use of natural resources and their impacts on ecosystem functioning so as to maintain ecosystem services • establishment of limits of acceptable change/carrying capacities based on key sustainability indicators such as availability of freshwater sources, infrastructure capacity and local socio-economic considerations • designation of land for appropriate uses, including 'zoning' as part of longer-term planning, based on assessment of 'carrying capacities' for tourism and other potential activities, and which take a long-term view • clear and unambiguous legislation setting responsibilities for public authorities and enforcement agencies.
2	Monitoring of changes and trends before, during and after developments are introduced, including effects on local/indigenous communities and use of natural resources.
3	Introduction of effective systems to monitor compliance with laws, and to take rapid enforcement action in cases of non-compliance.
4	Building coherence between different policy areas, government departments and public authorities to minimise conflicts between objectives, and to co-ordinate administration, including adoption of integrated pollution prevention and control.
5	Use of mechanisms to resolve resource use conflicts where the same resources are the basis for different socio-economic activities, including involvement of all stakeholders.
6	Promotion of appropriate environmentally sound technologies and management approaches.
7	Education and awareness raising programmes for the public and private sector actors involved in tourism, as well as for tourists and host communities.
8	Strengthening of linkages within the local economy to increase the benefits of tourism without increasing the number of tourists.

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7

Tourism in Desert and Savannah Regions

Robert Preston-Whyte, Shirley Brooks and William Ellery

Introduction

Arid landscapes have been constructed in many forms over the past two centuries. As landscapes of the mind, they take shape through the collection of senses that structure experiential space. As landscapes of ideology, they have been manipulated by power interests from the British and French colonial empires to Saddam Hussein, from the settlement hopes of western pioneers in the USA to the visions of ecotourist planners, from the certainty of scientific interventions to the chaos of social transformations. As landscapes of opportunity, drylands have been invented and reinvented by wave upon wave of interests, from exclusionary conservationists to enthusiastic ecotourist operators. As landscapes of Edenic dreaming, they have been painted as a romantic frontier, a space where mind and heart converge. As landscapes of distress they have been associated with the hurt and disruption of forced removals, from native American communities to Aboriginal Australians, from the San people in Botswana to apartheid victims in South Africa. These are spaces ruptured by multiple constructions, by multiple heterotopias, and by multiple realities, yet they retain a magnetism that is tangible, albeit elusive.

> The greatest part of my satisfaction was animal pleasure: the remoteness of the site, the grandeur of the surrounding mesa-like mountains and rock cliffs, the sunlight and the scrub, the pale camels in the distance, the big sky, the utter emptiness and silence, for round the decay of these colossal wrecks the lone and level sands stretched far away.

writes Theroux (2003: 81), referring to the temple complex at Al Nagger in the Sudan. This feast of sensory stimulation, coupled with the tantalising mystery of lost cultures, unfamiliar landscapes and unusual plants and animals, goes a long way to explaining why arid environments may be considered one of the ‘wonders of the world’ in their extent and stark beauty. In addition to the ways they have been constructed, manipulated and used in the recent past, these landscapes contain some of the most impressive examples of human occupation of the earth, from ancestral hominid fossils in eastern and southern Africa, to the pyramids of Giza and the lines of Nasca.

Particularly in Africa, drylands provide the habitat for vast herds of animals, predator and prey. As 'safari' landscapes of masculine identity, they have for centuries attracted sport hunters, adventurers and, more recently, wildlife tourists. But all this can change, and indeed *is* changing rapidly in some places, as tourists become the agents of destruction of cultural artefacts (Keenan 2002), as fauna and flora are threatened by competition with land-hungry humans and changing climate, and as global economic interests as well as local authoritarian states and marginalised people undergoing rapid social change become embroiled in violent conflicts over land use and resources.

What then of the future? It is difficult to be optimistic about tourism in arid lands. These are fragile environments, both in terms of their cultural heritage and biodiversity. The nomadic pastoralist communities that have successfully inhabited them for centuries are threatened with sedentarisation and exclusion from their former lands. Contemporary land use, with its razor-sharp divisions between productive and unproductive land, raises questions about sustainability. Issues of population pressure and the possibility of future warmer and drier climates modifying ecosystems in various ways are also troubling, and the concomitant stress on soil, water, ecology and food resources may cause already fragile social and governance systems to reach breaking point. These stresses are exacerbated by the globalisation of markets that tend further to impoverish marginalised communities: the environmental impact of extractive activities in dryland environments can be seen from space (Girard and Isavwa 1990; Tucker *et al*. 1991). Add to this an additional load of uncaring tourists and the burden may prove intolerable.

This chapter is about tourism and change in dry environments. The triangular linkage between natural environments, host communities, and tourist providers and consumers is one of interdependence. Break any one and the triangle collapses. Given these linkages, we discuss in separate sections the nature of arid environments and changing biodiversity, the attraction of these environments for tourists and their impacts on local communities and, finally, tourism as an agent of sustainable development.

Arid landscapes, biodiversity and desertification

The various constructions of arid landscapes cannot avoid the limits imposed on people, plants and animals by lack of water. As early as 1894 Albrecht Penck identified dry areas as those in which evaporation was either equal to or greater than rainfall. In their global map of areas of interior drainage basins, which included non-flowing or arheic regions, de Martonne and Aufrere (1927) recognised the link between endorheism and the fact that rainfall was insufficient to force drainage to the sea. As such, deserts were associated with endorheism. For mid-twentieth century soil scientists, rainfall insufficient to flush out soluble carbonates from surface layers to a depth beyond the reach of plant roots was considered a primary indicator of aridity (Shantz 1956).

Climatologists initially solved the problem of defining arid lands by relying on the work of botanists since maps of world vegetation predated maps of global climate. The remarkably similar vegetation structure of widely separate dry environments – widely spaced, single- or multiple-stemmed trees, low shrubs, grasses and/or short-lived herbaceous plants – is indicative of independently evolved modes of plants using sparse water and surviving erratic droughts. It was found that the distribution of vegetation based upon plant life forms could be used to map climate (Raunkaier 1934). For example, Köppen (1923), using the distribution of xerophytes (plants adapted to dry conditions), devised a classification of global dry climates based on an existing vegetation classification system and map. Thornthwaite (1948) devised a series of indices that showed the relationships between precipitation (water supply) and evapotranspiration (water demand), thus introducing the concept of precipitation effectiveness into the debate about how to define dry climates. In the late 1940s, the United Nations requested that a map of the arid lands be produced and, in response, Meigs (1953) extended Thornthwaite's method to calculate a moisture index that represented the relationship between precipitation and evapotranspiration. Various modifications since then (United Nations 1977a; Rogers 1981; United Nations Environment Programme 1992) show approximately 39.7 per cent of the global land area to be arid or semi-arid (Figure 7.1).

In dry environments the main constraint on biological productivity and human carrying capacity is the absence of water. In these environments plant life varies from true desert, dominated by short-lived annual plants that survive unfavourable periods as seed, to landscapes dominated by shrubs that are often succulent, to a combination of shrubs and grasses, to grasslands with or without scattered trees. Animal life varies along a similar gradient, with body size tending to increase with increasing moisture availability. The most abundant animal life occurs in savannahs, where the combination of plant productivity and forage nutritional value is optimal. Towards the drier end of the spectrum, plant productivity tends to limit

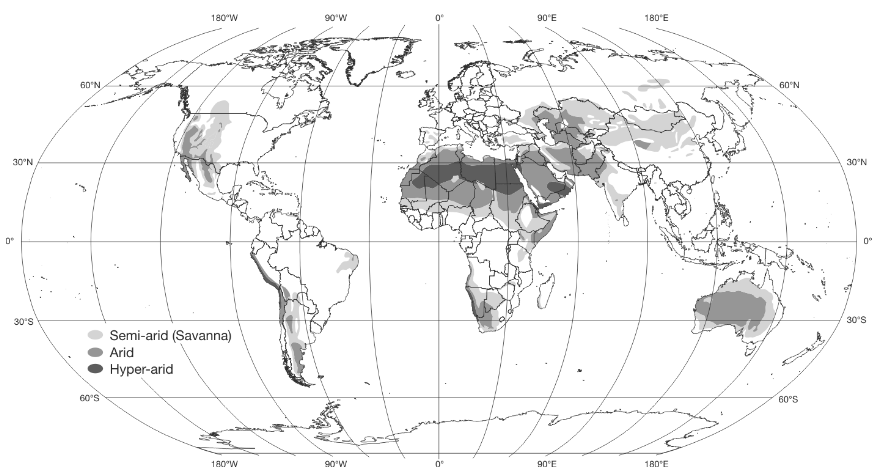

Figure 7.1 Global distribution of hyper-arid, arid and semi-arid (savannah) regions

faunal biomass, whereas towards the wetter end of the continuum nutrient concentration in plant tissue limits animal productivity (Ellery *et al*. 1995). It is worth noting that, along with animals, human populations in arid areas have also evolved patterns of migration in response to variability in rainfall and plant and animal production.

Key developments in the scientific understanding of drylands throw new light on the way these ecosystems respond to spatial and temporal environmental variability and disturbance. It is clear that environmental variability occurs on various spatial and temporal scales measured in seasons, years or decades in the case of rainfall variability. Despite these patterns of temporal variation, certain types of vegetation may continue to persist, suggesting a level of system equilibrium. Skarpe (1991) calls these systems 'resilient'. While vegetation systems may be resilient to rainfall variability, human-induced disturbance such as continuous grazing leads to dramatic changes in vegetation composition and structure, leading to system change from one state to another (Noy-Meir 1982). Such systems are termed 'unstable'. There is general agreement that semi-arid and arid ecosystems are resilient but at the same time tend towards instability (Thomas and Middleton 1994), and that recovery following anthropogenic disturbance is particularly slow because of the rarity of occasions on which sufficient moisture is available (United Nations 1977b).

Irreversible anthropogenic disturbance in arid lands leading to alteration of ecosystems is referred to as desertification. The causes of desertification have been widely attributed to agricultural neglect and misuse of the natural resources in arid environments; to land-use practices which degrade natural vegetation cover and impact negatively on the hydrological cycle and soil fertility and structure (Timberlake 1985). Although the effects of various forms of land use are debated (Tiffen *et al* 1994; Leach and Mearns 1996), the consequences of desertification are clear. They include the expansion of annual grasses and herbs at the expense of perennial grasses, increased incidence of short multi-stemmed trees – 'bush encroachment' – and damage to soils through salinisation, nutrient loss, compaction, crusting and erosion (Thomas and Middleton 1994).

Climate induced change also needs to be considered. There is general consensus that the trend towards warmer conditions evident over the past century will continue (Houghton *et al* 1990; IPCC 1997). Under these conditions, rising temperatures would increase evapotranspiration rates in arid areas, leading to a decrease in potential water availability. The effect on biodiversity will differ from one area to another depending on whether regional warming trends are accompanied by concomitant changes in rainfall. Similarly, the effect that increased aridification consequent upon global warming may have on tourism will also vary by region. For example, in South Africa the predicted warmer and drier conditions (Hulme 1996; Hulme *et al*. 2001) may lead to better representation of the eutrophic or arid savannah at the expense of the dystrophic or moist savannah. This may be 'Bad news for tourism because arid systems often do not favour a high diversity of spectacular plants or large mammals that most tourists visit these areas to see' (Midgley *et al*. 2001: 5). On the other hand, the bush encroachment that can accompany desertification, particularly in enclosed protected areas from which human activity has been excluded, may reduce the attractiveness of savannah environments by making wildlife more difficult to see (Watson 1995; Bond *et al*. 2002).

Tourism attraction and impacts

The very fragility of arid environments and their 'extreme' nature is one of the factors that attracts tourists to visit them. For some tourists such environments may be invested with a spiritual significance and a liminal quality that elicit questions about the nature of existence and mortality. On a more prosaic level, tourists may want to observe or photograph the unique plants and animals that have evolved to cope with such extreme conditions, as well as the wide open landscape vistas and features such as the unusual rock formations often found there (White and Nackoney 2003). In contexts like the central Sahara, cultural heritage in the form of prehistoric rock art is an important attraction (Keenan 2002). Such rock art is also widely spread across dry environments in sub-Saharan Africa and elsewhere. In a globalising world, both savannah and more extreme desert environments are widely sought after by international tourism agencies, which package their products in the form of wildlife tourism, ecotourism or adventure tourism.

The special appeal of the savannah environment, in particular the African savannah landscape, for western tourists is well documented (Graham 1973; Anderson and Grove 1987; Norton 1996; Broch-Due and Schroeder 2000; Bassett and Zueli 2003). The African savannah is widely viewed as the archetypal wild environment, a place of unspoilt nature. The appeal of this 'safari' landscape – scattered thorn bushes, wide vistas, yellow grass, herds of animals – is reinforced by countless wildlife documentaries, tourist brochures, films and web advertising (Norton, 1996). As Adams and McShane (1992: 42) observe:

> We cling to our faith in Africa as a glorious Eden for wildlife. The sights and sounds we instinctively associate with wild Africa – lions, zebra, giraffe, rhinos, and especially elephants – fit into the dream of a refuge from the technological age. We are unwilling to let that dream slip away … the emotional need for wild places, for vast open spaces like the East African Serengeti Plain, persists.

The power of this landscape image, embodying primeval timelessness, is immense and is used in the marketing of these areas as tourism destinations (Brooks 2000).

Yet such images tend to obscure the fact that these are environments over which bitter struggles have been fought for both material and ideological control (Neumann 1995a, 1995b, 1996, 1998). Whether or not visitors and tour operators recognise their presence, the people that inhabit these environments are often clinging to a precarious livelihood in marginal conditions. In east and southern Africa, for example, the colonial and post-colonial state has had a major role in reshaping the landscape, creating huge national parks in conflict with the interests of both settled local communities and nomadic pastoralists who find themselves in competition with wildlife for the use of savannah plains (Homewood and Rodgers

1991; Neumann 1998; Johnsen 2000). As a result, local people in extreme environments often have contested relationships with the state: they have been moved around at its behest and are unlikely to trust power emanating from a distant capital city. Commercial tourism agencies – often closely linked to the very states that created this crisis of marginalisation – may fail to grasp the highly political nature of questions of environmental sustainability in dry environments. They generally fail to understand how the exploitation of nature or cultural sites for tourism plays into local politics and power struggles (Keenan 2003b).

Furze *et al*. (1996: 146) argue that 'tourism may provide a vehicle or conduit for translating the values that others hold for a natural area into benefits for those who live in or near it'. They caution, however, that tourism itself imposes problems and costs of its own, burdening the natural resources and the host society to an extent which may outweigh potential development benefits. Tourism in remote locations, such as those discussed in this chapter, has often taken the form of 'enclave tourism' (Freitag 1994; Brohman 1996). This occurs when tourism-related facilities are not oriented towards the local community, and most local people cannot afford to participate in or enjoy the services offered. Money generated within these 'enclaves' usually has very little impact on the local economy: tourism revenues tend to go to external agencies and may not even remain in the host country. While countries like Botswana have attempted to combat these trends, this is not always successful and often tourist enterprises in fragile environments exist in isolation from the surrounding communities (Mbaiwa 2003, 2004). If local people are expected to bear the costs of tourism development, and get none of the benefits, then it is obvious that problems will arise.

The devastating social effects of forced removals and reduction of grazing lands through the creation of national parks and other protected areas are widely known (Ghimire and Pimbert 1997; Johnsen 2000). It is increasingly recognised that, in the process of expanding conservation areas and tourist operations, local property rights need to be protected as far as possible – that 'the tradition of government appropriating all resource rights and centrally managing them has not worked to the benefit of either conservation or local development' (Furze *et al*. 1996: 156). In the past two decades, various experiments in community-based tourism and attempts to give communities greater local rights over wildlife and land have been pioneered in dry environments. In sub-Saharan Africa's savannah and semi-arid regions, debates about how to integrate national parks and the livelihoods of pastoralists are ongoing (Lindsay 1987; Thompson and Homewood 2002).

Outside of protected areas, landscapes are being reshaped by new discourses of community-based tourism in which communities are encouraged to link their livelihoods more closely – even to fully integrate them – with wildlife. This approach is widely viewed as the only hope for sustainable wildlife tourism (Murphree 1993; Western and Wright 1994; Hulme and Murphree 2001). If property rights are secure and power relations with partners in ecotourism enterprises fairly equal, this approach can work for communities in dry environments (Thomas and Brooks 2003). Yet there are also serious actual and potential costs associated with the linking of livelihoods so directly to tourism, which involves tolerating the presence of wildlife on grazing lands and reducing pastoralist activity. These two land uses – pastoralism and game farming – often prove mutually exclusive, and in dry environments such matters are literally life and death concerns (Keenan 2003a).

Livelihoods in dry environments tend to be constituted through multiple activities. It is often not sensible for those living in dry environments to rely on a single occupation. For example, as Kawatoko (2004) describes in his abstract to the United Nations University International Conference on Marginal Drylands in Tokyo, for life in the Sinai peninsula:

> There has been not only fruit cultivation in the orchards (date palm and others), agriculture, nomadism (camels, goats and sheep), firewood gathering and charcoal burning and drug plant gathering in the wadis, but also hunting in the mountains (wild goats, desert lizards, birds, etc.), hawk capturing, turquoise mining, and fishing and shell gathering on the seacoast.

The introduction of new tourism activities into fragile environments, even if old forms of land use are not totally abandoned, diverts the energies of host communities into other channels, with unpredictable social and environmental effects (Shackley 1996; 1999).

Even if livelihoods are not disrupted and the problems associated with 'enclave' tourism are overcome, the business of attracting tourists to arid environments is not a straightforward matter. Unfortunately the natural and cultural attractions of dryland areas are vulnerable to degradation and destruction by a range of environmental and human agents. If poorly managed, the appeal of dry environments may diminish, as the tourism experience is itself diminished. Externally driven narratives of desertification aside (Swift 1996), some residents of fragile dryland environments predict ecological catastrophe in the near future. Tourism contributes to this outcome, albeit inadvertently (Keenan 2002). In the case of the Sahara, the situation appears grim:

> [the area's] extraordinarily rich cultural and scientific heritage, so much of which seems to have survived over thousands of years the harsh vicissitudes of climate and other natural forces, has been subjected in the last two generations or so to extensive and largely irreversible damage.
>
> (Keenan 2002: 2).

Photographers moisten paintings so as to bring out the colour, thus damaging them irreparably; collectors 'vacuum' the Sahara for artefacts; tour operators open up new sites in an attempt to offer their clients a 'unique' desert experience. The increasing accessibility of such sites and their opening up to tourism sets in motion forces that need to be carefully controlled.

It is hardly surprising that host communities in dry environments may regard tourism with some scepticism. While states often welcome tourism and encourage their citizens to embrace it as a means of livelihood, there remains deep ambivalence as people also see tourism as posing a serious threat not only to their local environment but also to their way of life. The cultural consequences of tourism for people living in arid environments may be severe. Often these are people who, until recently, have been relatively sheltered from the winds of globalisation. Now, however, their cultures and way of life are ruthlessly exposed, transformed into marketable commodities in the cultural tourism marketplace (Kohl 2002; Dinero 2002). Occupants of these areas are rightly concerned about the effect of tourism on the moral and symbolic order of society (Hobbs 1996; Duffy 2002; Grainger 2003).

Some threats to tourism enterprises in such regions lie well beyond tourism management control. One such threat is the political instability and violent conflict often intertwined with the politics of the extraction of natural resources such as petroleum from semi-arid and desert regions (Watts 2001). Areas like these have become, in Watts' phrase, 'globalized local sites' due to the globalization of resource and biodiversity extraction and mining (Watts 2000: 22; Zerner 2000). Competing global and local interests intersect around questions of conservation and resource use in dry environments and tourism is only one part of the picture. Alliances between authoritarian governments, transnational oil corporations and the emerging world order are disturbing: they contribute to a deteriorating security situation and to broader dynamics of violence in fragile environments that are not conducive to tourism development (Watts 2001; Keenan 2003b). Tourists may want an exciting adventure but they do not want to endanger their lives.

As already mentioned another potential threat to tourism in dry environments is the impact of global climate change. In environments already subject to extreme climatic variability people are generally clinging to livelihoods that are more or less precarious. Predictions are that it is the world's drylands that will suffer the greatest reductions in water availability if significant global warming occurs. Scientists are currently engaged in debate as to whether or not recent decades of drought in regions like the Sahara–Sahel indicate real climatic change or simply variations within a medium-term norm (Durand and Lang 1991; Hulme 2001; Hulme *et al*. 2001). It is striking, however, that residents of dry environments do not perceive this threat in the same way scientists do. These people are accustomed to periods of prolonged drought, and their impressions of environmental change are more likely to be shaped by local understandings of the environment than by climate modelling (Benjaminsen 2000; Mortimore and Adams 2001; Graef and Haigis 2001). Keenan (2003b: 5) found that, in the Sahara, local people's ranking of 'climate change' as one of the agents that may 'turn their world upside down' is low. As host communities battle with pressing issues relating to their immediate survival, the hypothetical possibility of climate change is viewed as remote. It is with the contribution of tourism to these issues of sustainability and development that we end our discussion.

Tourism and sustainable development

The debate around global environmental changes brought about by human activities has brought into focus the present and future plight of billions of people who face an uncertain future (United Nations Development Programme 1998). Many of these people live in arid regions where their sustainability cannot be divorced from issues that contribute to poverty, disempowerment and desertification. Tourism in arid lands, with its relatively wealthy clientele often placed in juxtaposition with communities fractured by drought, unemployment, poverty, poor health and crime, presents a significant challenge to institutions wrestling with the notion of sustainability (Hall and Lew 1998; Honey 1999).

Tourism development in savannah and desert areas often brings with it the opening up of the commons to consumption demands and technological requirements that challenge resilience to change of social and ecological systems (Goldman 1998). Ensuring that development becomes sustainable means that complex questions such as demand- and supply-side constraints, corporate pressures, governance responsibilities, environmental impacts and ethical imperatives are raised. When complicated by global environmental changes that disturb the fragile balance between ecological resilience, social equilibrium and human-induced stress, the equation becomes even more difficult to compute. Host communities in such areas may then find themselves becoming increasingly vulnerable to forces that diminish their quality of life.

Adger and O'Riordan (2000: 165) note that 'vulnerability is a function of powerlessness' brought on by the inability of people to cope in situations where they are kept ignorant of the nature of the threats confronting them and, for a variety of reasons, prevented from intervening in their resolution. This situation usually arises where communities with limited access to power and resources find themselves to be the victims of political and economic ideologies that do little to protect local markets, press freedom and local investments in environments, and even less to control macro forces such as rapid urbanisation, decline in soil productivity and arms expenditure (Blaikie *et al*. 1994). The sustainability of such communities is threatened when the ethical, economic and political conditions that favour vulnerability are coupled with damage to the biophysical functions that sustain life. Sustainability is therefore dependent upon 'the coupling of both human resilience and ecological sensitivity into a single, interactive totality' (Adger and O'Riordan 2000: 165).

If tourism is to militate against rather than contribute to host community vulnerability in savannah and desert regions, two issues need to be borne in mind. The first is that there are many pathways to sustainability (O'Riordan *et al*. 2000) and these will be informed by differences between nations in relation to level of economic development, access to technology and resources, and governance strategies. The second is the need to build the four pillars of sustainability: secure wealth creation, stewardship, empowerment and 'revelation' (O'Riordan 2000). Each of these four pillars is considered in turn.

First, the sustainability of host communities must be grounded in their ability to generate wealth through tourism in a continuous and ecologically tolerable manner. Second, while stewardship means taking care of the environment upon which the community subsists, this may well entail the inclusion of second-order issues such as improving education and health, eliminating crime, corruption and environmental injustice. Third, when wealth creation and stewardship are in place community empowerment should follow. O'Riordan and Voisey (1998) see empowerment as a process that leads towards the development of personal self-respect and self-confidence and the development of a civic consciousness that ensures inclusiveness, legitimacy and accountability. Finally, this chain of events leads to the 'revelation' that a sustainable future is achievable through the visioning of a collective future:

> … involving programmes of reliable wealth creation, accountable distribution and opportunity provision for jobs and basic needs, social acceptance of the need to take care of network and social capital for self-preservationist reasons, and practically sensible but democratically realistic empowerment arrangements.
> (O'Riordan *et al*. 2000: 3).

It is difficult to find examples in dry environments where tourism has led to empowerment and sustainable development. Perhaps they exist and lack visibility. More common are examples where the scorecard of sustainability indicators is less than satisfactory. Honey (1999) for example, provides an analysis of the path towards ecotourism sustainability in Tanzania, Kenya and South Africa. For historical, ideological and economic reasons, each country is at a different stage along the development path. In each case, issues like the building of environmental awareness, minimising environmental impacts, the empowerment of local people, the provision of financial benefits for conservation, and respect for local cultures all need attention before tourism can become a force that can make a positive contribution to global and globalising changes and local problems of corruption, mismanagement and poor governance.

Conclusion

When tourists visit desert and savannah areas in sizeable numbers they become part of an inevitable process of change that impacts in various ways on the natural environment and local communities. The perspective developed here envisages tourism, natural environment and community development at each corner of a triangle. The triangle metaphor is used because it brings into focus the elements that structure the relationship between tourism and global environmental change in arid regions, while also emphasising the powerful linkages between them. It also stresses the importance of exogeneous shocks to the natural environment or stability of local communities which, through breaking the links binding the triangle, would severely impact on tourism demand. It is recognised, however, that for a more detailed and thorough understanding of the dynamic issues that inform the interactions between tourists, physical environment and local communities a network metaphor may be a more appropriate analytic tool.

The links between tourism, natural and social environments in a changing world open up a range of scenarios. At one end, tourism may benefit local communities and the natural environment by encouraging a setting where humans and nature learn to live together in a state of mutual respect and understanding. At the other end, tourism may impact on the natural and social environment in ways that are socially destructive and environmentally irreversible. In between, tourism demand for arid landscapes may contribute to scenarios that produce widely ranging mixes of social impact, economic development and biophysical variability. How, when and where these scenarios play themselves out in response to global environmental changes remains to be seen. The curtain has risen; the play has begun.

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8

Environmental Change and Urbanization of Tourism

C. Michael Hall

At the start of the twenty-first century the world is more urbanised than ever before and the rate of urbanisation continues to grow. On a global scale, about three billion people, or approximately 48 per cent of the world's population live in urban areas and by the year 2030 this is set to rise to 61 per cent (United Nations (UN) 2004). It is estimated that in 2007 more than half of the world's population will live in urban areas. This will be the first time that the world's urban population has exceeded the rural population. The urban population reached one billion in 1960, two billion in 1985 and three billion in 2002. It is projected to rise to 4 billion in 2017 and 5 billion in 2030. During 2000–2030, the world's urban population is projected to grow at an average annual rate of 1.8 per cent, nearly double the rate expected for the total population of the world (almost 1 per cent per year). Given this expected rate of growth, the world's urban population will double in 38 years or in about half the lifetime of a person. However, almost all the expected growth in urban populations will be in the less developed countries, averaging 2.3 per cent population growth per year. In contrast, the urban population of the developed countries is expected to increase from 0.9 billion in 2003 to one billion in 2030, representing an annual growth rate of 0.5 per cent per annum, in contrast to the 1.5 per cent recorded during the previous 50 years. This slowing of the urban population growth rate is hardly surprising given that 74 per cent of the population in developed countries already lived in urban regions in 2003. Nevertheless, this figure is forecast to increase to 82 per cent by 2030 (UN 2004).

There are also substantial regional differences with respect to the degree of urbanisation. For example, Latin America and the Caribbean are highly urbanised, with 77 per cent of their population living in urban areas in 2003. This proportion is twice as high as for Africa and Asia, which had 39 per cent of their populations living in urban areas in 2003. It is expected that Africa and Asia will experience rapid rates of urbanisation during 2000–2030, so that by 2030 54 per cent and 55 per cent, respectively, of their inhabitants will live in urban settlements. Over the same time period, 85 per cent of the population of Latin America and the Caribbean will have become urbanised. In Europe and Northern America, the percentages of the population living in urban areas are expected to rise from 73 per cent and 80 per cent, respectively, in 2003, to 80 per cent and 87 per cent in 2030. The increase in Oceania is likely to be from 73 per cent to 75 per cent over the same period (UN 2004).

It is not just the proportion of the world's population that live in urban areas which is growing, but also the size of those urban areas. Over the past 50 years more and more cities have populations of one million or more inhabitants. With some rare exceptions (for example, Imperial Rome and Edo in the thirteenth century), the city of several million inhabitants is a phenomenon of industrial modernity. In 1950, only 29 per cent of the world's population of 2.5 billion were urban dwellers and 83 per cent of the developing world's people were still living on the land. By 2030 it is expected that over 60 per cent of the world's 8.13 billion global citizens will be living in towns and cities (UN 2004). In 1990, the average size of the world's 100 largest cities was around 5.1 million inhabitants, compared to 2.1 million in 1950, around 700,000 in 1900 and just under 200,000 in 1800 (Sadowski *et al*. 2000).

In the second half of the nineteenth century London became the first city to have several million inhabitants. By 2003, there were 46 cities with more than five million people, including 20 'megacities' with more than 10 million people (UN 2004). With 35 million inhabitants in 2003, Tokyo is by far the world's most populous urban agglomeration. After Tokyo, the next largest urban agglomerations in the world in 2003 were Mexico City (18.7 million), New York/Newark (18.3 million), São Paulo (17.9 million) and Mumbai (Bombay) (17.4 million). In 2015, it is expected that Tokyo will still be the largest urban agglomeration with 36 million inhabitants, followed by Mumbai (22.6 million), Delhi (20.9 million), Mexico City (20.6 million) and São Paulo (20 million). It is projected that by 2015, 22 cities will have populations of over 10 million, with all but five of these megacities being located in the less developed world. The population of these 22 cities in 2015 will be about 358 million – 75 million more than today, but still only about 5 per cent of the expected global population of over seven billion.

In 2003, 33 of the 46 cities with five million inhabitants or more were in less developed countries, and by 2015, 45 out of the 61 cities are expected to be from the less developed regions (UN 2004). Although considerable attention is given to the growth of these megacities, and the problems of urbanisation that they will face, it should be noted that it is predicted that by 2030 three quarters of the world's anticipated population growth will live in cities with populations between one and five million and 16 per cent in cities of over five million people. Given this scale of change it is therefore hardly surprising that the UN (2004: 3) reported:

> [three quarters] of all governments report that they are dissatisfied with the spatial distribution of their populations … The speed and scale of this [urban population] growth, especially concentrated in the less developed regions, continue to pose formidable challenges to the individual communities as well as the world community.

Given the growth of the world's population in cities it is therefore unsurprising that urbanisation is a significant factor in global environmental change (GEC), constituting not only a major factor in land use and land cover in the immediate area of urbanisation but having relational effects on other regions because of the demands the cities generate for energy, materials, natural resources and food, as well as disposal of urban wastes, particularly in peri-urban areas (Tacoli 1998; Allen *et al*. 1999; Pickett *et al*., 2001; Gurjar and Lelieveld, 2004). Nevertheless, as Kötter (2004: 8) recognised:

> Urban agglomerations are complex and dynamic systems that reproduce the interactions between socio-economic and environmental processes at a local and global scale. Despite their importance for economic growth, social well-being and sustainability of present and future generations, urban areas have not received the level of attention they require in the study of global environmental change

(see earlier comments by Setchell (1995) and Satterthwaite (1997) in relation to issues of sustainable development).

Urban systems *per se* actually occupy only a small percentage of the world's land surface – just 1 per cent (Grubler 1994). Although clearly there will be bioregions of the world where this figure will be much higher. Indeed, Allen *et al*. (1999) argue that in countries with high population growth rates, urban development can actually reduce land pressures in rural areas that are becoming too densely populated. Nevertheless, the expansion of cities clearly has an environmental impact in terms of land conversion. For example, in São Paulo, Brazil, the urban core grew from an area of 180 km^2 in 1930 to more than 900 km^2 in 1988. The metropolitan region is even larger, covering 8000 km^2. While the extent of land conversion through urbanisation is substantial, it is just as important to recognise that certain types of land are being converted. In the case of São Paulo:

> Prime agricultural land and forest have been converted to urban uses, and development is beginning to move onto steep slopes, which include some of the region's last remaining reserves of natural vegetation. Urban expansion is also threatening the local watershed.
>
> (WRI 1996: 59)

Concentrating economic activity and consumption in cities has both direct and indirect environmental impacts. The direct environmental impacts are the result of producing levels of pollution which environmental resources such as water bodies, acting as waste sinks, cannot sustainably absorb. 'The breakdown of local and global ecosystems and the health consequences of such levels of pollution are manifest' (Forbes and Lindfield 1998: 9). As centres of consumption and production as well as a specific land use cities can have a substantial ecological footprint (Rees 1992). For example, the United Nations Environment Programme – International Environment Technology Centre (UNEP–IETC 2003) states that the ecological footprint of the Greater Tokyo area is 3.5 times the land area of Japan as a whole, while London's is equal to the land area of UK. However, the role of cities in global change is regarded as more than environmental in scope. Processes of contemporary economic and socio-cultural globalisation and associated global change are seen by many commentators as being inextricably linked to the growth of world cities as well as competition to be a world city. 'The result is a "smaller" world, in which our lives are lived and shaped through the global metropolitanism of "larger" cities' (Knox 1995: 232). Significantly for globalisation processes, embedded within larger cities 'are the nodal points of a "fast world" of flexible production systems and sophisticated consumption patterns' that can be contrasted with 'the "slow world" of catatonic rural settings, declining manufacturing regions, and disadvantaged slums, all of which are increasingly disengaged from the culture and lifestyles of world cities' (Knox 1995: 232–3). Indeed, the footprint of the city is clearly more than ecological in scope although it has substantially shifted the dependence of cities on their surrounding bioregion. As Harvey (1996: 412, 413) observed:

> Each bundle of innovations [transportation, communications, etc.] has allowed a radical shift in the way that space is organised and therefore opened up radically new possibilities for the urban process. Breaking with the dependency upon relatively confined bioregions opened up totally new vistas of possibilities for urban growth … [T]he development of an interrelated and ultimately global network of cities drawing upon a variety of hinterlands permits an aggregate urban growth process radically greater than that achievable for each in isolation.

Tourism urbanisation

Tourism is embedded in processes of urbanisation in two fundamental ways. First, as the main driver behind urbanisation in places that are very specific urban production spaces for tourism and leisure, what Mullins (1994) has described as 'tourism urbanization'. Second, as a routine element of leisure production in urban space in which, although certain parts of urban land use may be substantially geared toward satisfying tourism consumers and leisure mobility, the city's economy is not dominated by tourism and leisure production (Page and Hall 2003). Mullins (1991:, 326) explained the phenomenon of tourism urbanisation as:

> Cities providing a great range of consumption opportunities, with the consumers being resort tourists, people who move into these centres to reside for a short time … in order to consume some of the great range of goods and services on offer.

The purpose of consumption is pleasure-related. Mullins (1994) described tourism urbanisation as a new urban form, although such an argument is highly debatable given the rapid development of resort towns for holidaymaking and day-tripping in the industrialising countries during the nineteenth century (Towner 1996). Examples would be towns such as Blackpool, Margate and Southend in the United Kingdom and Atlantic City in the United States. However, in the late twentieth century what did become different, and what characterises the 'new urban tourism' (Page and Hall 2003), is the scale, complexity and diversity of consumption experiences which now exist in urban landscapes built specifically for tourism and leisure as a result of processes of space–time distanciation and increased levels of disposable income. Several cities and regions around the world are now economically geared towards such consumption, including the Gold Coast and the Sunshine Coast in Australia, Honolulu, Reno and Las Vegas in the United States, Blackpool in the United Kingdom, Whistler and Niagara Falls in Canada, the Algarve in Portugal, and the Costa Brava in Spain. However, such cities and regions are only the more obvious examples of the many tourism and leisure specialised communities that have developed in the resort regions of the world. Tourism urbanisation 'based on the sale and consumption of pleasure' (Mullins 1991: 331), is identified by a number of characteristics (see also Page and Hall 2003), that makes such places:

- Spatially and functionally different from other urban places. For example, the amenity-driven nature of much tourism means that along many coastal areas tourism urbanisation is highly linear.
- Symbolically different, with various images and symbols as well as a commodified urban environment being used to promote the tourist function.
- Characterised by rapid population and labour force growth in the early stages of development. Even as urban growth slows, the population and labour force tends to have a relatively high degree of transience, underemployment and unemployment as a function of construction cycles and the temporal nature of tourism consumption and production.
- Distinguished by flexible forms of production, particularly in terms of a highly flexible labour force organised to meet daily, weekly and seasonal changes in consumption (usually through high-rates of part-time and casual employment and low-rates of unionisation).
- Dominated by state intervention which has a 'boosterist' tendency, whereby government indirectly invest in the facilities infrastructure with a view to encouraging further inward investment.
- Associated with large-scale pleasure production that simplifies the local economy and requires substantial importation of goods, services, water and energy from outside the resort region in order to meet the demands of a highly mobile population.
- Subject to substantial transformation of amenity landscapes for tourism production and consumption.
- Foci of transport networks because of the need to import and export not only goods and services but also the tourists themselves.

Tourism urbanisation tends to be focused in high value amenity environments and is associated with other forms of amenity-related urbanisation, particularly in coastal areas (Mullins 1990, 1999; Hall 2005). Nearly three quarters of the world's population live within 100km of a sea coast or lake shore (CO-DBP 1999) and urbanisation in coastal areas is increasingly regarded as being a global problem (e.g. German Federal Agency for Nature Conservation 1997; Intergovernmental

Oceanographic Commission 2000; United Nations Centre for Human Settlements (Habitat) 2001). For example, urbanisation and urban sprawl are a major problem along large areas of Europe's temperate and Mediterranean coastlines. More than 70 per cent of the coast from Barcelona to Naples had been developed by 2000 (CO-DBP 1999). Over a third of Europe's total population live within 50km of Europe's coasts and that figure is growing. By 2025, the percentage of the population of Spain, France, Greece, Italy and the former Yugoslavia living in coastal cities is projected to be more than 85 per cent on average, and as high as 96 per cent in Spain (Stanners and Bourdeau 1995; CO-DBP 1999). The environmental impact of urbanisation of the Mediterranean cost is, of course, greatly exacerbated by the scale of visitation by temporary residents who have second homes along the coast, as well as the large numbers of tourists. As the Parliamentary Assembly, Council of Europe (2003: 2.28) state:

> There is little doubt that human-induced causes, such as population pressures, urbanisation, over-construction, and ill-planned development (as well as protection) of the Mediterranean coasts have led to much of its deterioration or destruction. Many of these human-induced pressures stem from or are closely linked to tourism.

The World Wide Fund for Nature (WWF 2001) estimate that in 2000 the Mediterranean region received approximately 30 per cent of all international tourist arrivals. In 1999 international tourism totalled 219.6 million arrivals – by 2020 WWF estimate that this figure will have grown to approximately 355 million tourist arrivals, representing about 22 per cent of international tourist arrivals (WWF 2001; De Stefano 2004). These figures do not include the travel behaviour of domestic tourists who also utilise the coastal areas. According to the WWF (2001: 2): 'the projected growth of tourism development in the region will continue to damage landscapes, cause soil erosion, put pressure on endangered species, further strain available water resources, increase waste and pollution discharges into the sea and lead to cultural disruption.'

Tourism and amenity urbanization has therefore contributed to substantial pressures on Mediterranean coastal landscapes. Three quarters of the sand dunes of the Mediterranean coastline from Spain to Sicily have disappeared. According to the WWF (2001) this is mainly a result of urbanisation linked to tourism development. Tourism urbanisation is also held to be primarily responsible for the urbanisation of the Italian coast. In Italy over 43 per cent of the coastline is completely urbanised, 28 per cent is partly urbanised and less than 29 per cent is still free of construction. There are only six stretches of coast over 20km long that are free of construction and only 33 stretches between 10 and 20km long without any construction (WWF 2001).

Tourism urbanisation is also impacting the coast of Tunisia. According to De Stefano (2004), the urbanised coastal area of Tunisia extended for 140km and tourist areas occupied by hotels and second homes occupy approximately a further 80km of the total urbanised linear space. The combined urban coastline of 220km represents approximately 18 per cent of the total Tunisian coastline. De Stefano (2004) argues that when current and planned tourism projects are accounted for, about 150km of the shoreline will eventually be occupied by tourism and leisure facilities and infrastructure. She goes on to note that inappropriate siting of tourist infrastructures on foredunes is accelerating the process of beach erosion and altering the water dynamics of the coastal region. Similarly, in Cyprus, 95 per cent of the tourism industry is located within 2km of the coast (Loizidou 2003) placing the coastal environment under extreme pressure. Under the Cypriot land-use zoning system in 1997–98, 37 per cent of the coastline (in length) was zoned for tourism, 12 per cent for agriculture, 6 per cent for residences and 3 per cent for industry. The remainder (43 per cent) was zoned as open area/protected natural or as archaeological areas. However, it is expected that future revisions of land-use planning zones will see more of the coast zoned for tourism use (Loizidou 2003).

Ecosystem stress

The focus of tourism urbanisation on the coast also means that many of the Mediterranean coastal ecosystems are under severe stress, with over 500 plant species threatened with extinction. Although the most severe environmental pressure is on the land–sea interface, the Mediterranean Sea is also suffering from severe environmental stress with over 10 billion tones of industrial waste per year estimated to be dumped in the Mediterranean with little or no purification. No figures are available specifically on the amount of waste generated by tourists. However, in OECD countries, municipal waste per capita increased from 410kg to 510kg per year from 1980 to 1995, and total waste generated increased from 347 million tonnes to 484 million tonnes within the same period (United Nations Centre for Human Settlements (Habitat) 2001: 69).

The generation of waste and therefore the placing of increased stress on ecosystems is usually exacerbated by the seasonal pressures placed on sewage and water systems by tourism (German Federal Agency for Nature Conservation 1997). Indeed, one of the most substantial impacts of tourism urbanisation in the Mediterranean is regarded to be the overall pressure that is being placed on freshwater supplies, particularly through aquifer overexploitation (CO-DBP 1999). Not only because of direct demands of tourism for the immediate water needs of tourists but also because of the impacts of tourism urbanisation on coastal wetlands and lagoons (De Stefano 2004).

The main causes of impact on freshwater ecosystems because of tourism urbanisation are as follows.

- Higher water consumption due to population increase – this includes both tourists and the flexible workforce required for tourism production. For example, in the Balearic Islands (Spain), water consumption during the peak tourism month in 1999 (July) was equivalent to 20 per cent of that by the entire local population in the entire year (De Stefano 2004).
- Higher consumption of water for tourist facilities.

- Peaks in wastewater volumes and the stresses that causes for wastewater treatment facilities. Scoullos (2003) reports that only 80 per cent of the effluent of residents and tourists in the Mediterranean is collected in sewage systems with the remainder being discharged directly or indirectly into the sea or to septic tanks. However, only half of the sewage networks are actually connected to wastewater treatment facilities with the rest being discharged into the sea. The United Nations Environment Programme Mediterranean Action Plan Priority Actions Programme (UNEP/MAP/PAP 2001) estimated that 48 per cent of the largest coastal cities (over 100,000 inhabitants) have no sewage treatment systems, 10 per cent possess a primary treatment system, 38 per cent a secondary system and only four per cent a tertiary treatment system.
- Inappropriate siting of tourism facilities and infrastructure on foreshores, dune systems and wetlands. UNEP/MAP/PAP (2001: 14) observed that mass tourism exacerbates issues of urbanisation impacts: 'leading to habitat loss for many wildlife species', and estimated that, since Roman times, the wetland area of approximately three million hectares then has been reduced by 93 per cent. Of this, one million hectares has been lost in the last 50 years (Parliamentary Assembly, Council of Europe 2003: 2.12).

Construction

The Mediterranean experience serves to highlight the extent to which tourism urbanisation acts as a particular urban form. Loizidou (2003) refers to a long 'coastal wall' of tourism development on the island of Cyprus. Such urban structures will clearly not only have long-term environmental effects but will also have significant impacts during their construction phase. According to UNEP-IETC (2003), on average the construction industry accounts for over 35 per cent of total global CO_2 emissions (building operation 10.2 per cent, business operation 9.2 per cent, materials production 10.9 per cent, transport 5 per cent, construction work 1.3 per cent), more than any other industrial activity. Significantly, the construction industry also tends to have substantial impacts on the peri-urban area of large cities as bulky and low value materials, such as building materials, are usually drawn from the immediate region of cities. This results in the proliferation of extractive activities such as claypits, quarries, brickworks and gravel pits thereby further extending the ecological footprint of cities. The CO-DBP (1999), in their examination of the impacts of urbanisation in the coastal regions of Europe, estimated that quarrying of sand and mineral aggregates for the construction of urban dwellings represents approximately 20 per cent of the total land lost to urbanisation.

Climate

Urban areas also have significant climatic effects. Urban form interacts with solar and anthropogenic radiation; absorbing and emitting heat, and leading to the urban heat island (UHI) effect (Baker *et al*. 2002; Arnfield 2003; Dixon and Mote 2003;

Samuels 2003). The relationship of urban versus rural climatic data to population change is pronounced over time (Brazel *et al*. 2000). However, the overall contribution of urban effects on twentieth-century globally and hemispherically averaged land-air temperature-time series do not exceed about 0.05°C over the period 1900 to 1991 (IPCC 2001a; see also Jones *et al*. 1990, 1999; Easterling *et al*. 1997) although the IPCC do note that 'greater urbanization influences in the future cannot be discounted' (2001: 105).

The greatest effect of urban areas on climate is their function as heat islands. Yet these are meso- and micro-climatic effects rather than an impact on the global climate. Nevertheless, given the number and distribution of urban areas around the globe, such UHI effects are global in distribution. No literature exists on the specific climatic dimensions of tourism urbanisation, although bioclimatic conditions and the thermal environment have been found to be significant impacts on leisure behaviour in urban parks (Thorsson *et al*. 2004). High-rise, high thermal-mass building canyons like those found in many central business districts also serve to magnify the impact of the built environment on urban climate. In a study of climate variablility of urban sites in Athens, Greece, Santamouris *et al*. (2001) reported that the average daily heat island intensity for the urban sites was approximately 10°C with a maximum value of around 15°C. Increases in temperature also result in increased rates of ozone formation (Duefias *et al*. 2002). However, much of the UHI effect can be mitigated by increasing tree density (Saito *et al*. 1990), which also has benefits in terms of reducing energy emissions and carbon combustion (Akbari 2002).

Differences between urban and rural/natural meso-climates occur on two different scales. First, the urban canopy layer – which is the air contained between the urban roughness elements, usually buildings – and its condition is determined by the nature of the site materials and geometry of the immediate surroundings. Second, the urban boundary layer which is the portion of the planetary boundary layer whose characteristics are determined by the urban region at its lowest boundary, usually regarded as roof level (Oke 1976; Williamson and Erell 2001). There are five main areas of difference between the climate of urban areas and that of the rural/natural surroundings: the radiation budget, sub-surface (storage) heat flux, advection (horizontal convection), anthropogenic heat release, and turbulent heat transfer including the effects of vegetation. There is no evidence to suggest that tourism urbanised area will be any different from other urban areas, with the possible exception of the linear form of tourism urbanised spaces in coastal regions and the deliberate development of some resorts in peripheral or alpine locations. For example, if evidence from other locations with substantial winter snowfall (e.g. Hinkel *et al*. 2003) was to be extrapolated to winter ski resorts then it is highly likely that the urbanised areas of ski resorts experience earlier snow melt and generate a significant heat island effect. Nevertheless, the effects of climate change on human comfort levels arguably need to be better understood in urban areas than they do in other tourism locations because of the complicating effects of urban micro- and meso-climates on comfort. However, climate knowledge has been poorly utilised in urban planning (Eliasson 2000), let alone tourism planning.

Conclusions

Tourism urbanisation and tourism and leisure mobilities in urban areas lead to environmental change on a global scale, with some regions experiencing more substantial change than others by virtue of the concentration of tourism urbanisation in desirable amenity landscapes. These environments, of which the Mediterranean is the most noted example, are undergoing severe environmental stress. Gössling (2002) estimated that an area of more than 514,950km^2 had been affected by tourism-related land alterations. However, as with nearly all urban areas, the ecological footprint of such tourism land use is clearly far greater. Yet such an assessment does not provide for an understanding of the environmental footprint of tourism development that considers the 'cradle-to-grave' impact of that development upon environmental capacity (Hall 2000; Ravetz 2000). Moreover, tourism urbanisation arguably has certain characteristics that only serve to reinforce other elements of GEC processes because of the extent to which it links social, economic and environmental dimensions of GEC (O'Brien and Leichenko 2000). In addition, tourism urbanisation has spatial and locational characteristics that tend to concentrate land-use impacts in certain environments, particularly coastal and mountain areas, as well as in the peri-urban regions of urban centres as a result of day-trip activity, although the networks that link such areas with generating regions are also clearly significant. It is, therefore, perhaps ironic that it is precisely the areas in which tourism urbanisation is most likely to occur that are arguably the most vulnerable to the environmental and economic impacts of global climate change through sea-level rise and global warming.

Undoubtedly, low lying coastal areas are among the most vulnerable to sea-level increase and storm surges. Coastal populations are continuing to grow rapidly in developed countries as a result of amenity and lifestyle migration and tourism development. However, it should be noted that globally the coastline is a major focal point of human settlement with approximately a quarter of the world's population living in the near-coastal zone (Nicholls 1995; Small and Nicholls 2003). Nicholls (2004) reports on a range of coastal flooding scenarios and highlights that millions of people will be affected, even given assumptions of flood mitigation and protection measures. Obviously, many of these populations will be in developing countries and in major river estuaries such as in Egypt and Bangladesh. Nevertheless, the continuing development of coastal regions as a result of tourism urbanisation, such as in Florida, coastal Mediterranean and south-east Queensland is seemingly likely to be under increased threat as a result of sea-level increases and potential climate variability. Biogeophysical effects include flooding and storm damage, wetland loss and change, coastal erosion, saltwater intrusion and rising water tables (Nicholls and Lowe 2004). Many of these effects will potentially impact future coastal tourism urbanisation. Nevertheless, in many locations the lure of 'a place by the beach' seems to be stronger than the threat of environmental change. In such locations, it may well need a storm event to encourage new behaviours with respect to coastal planning and development rather than predictions.

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