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Résumé de l'article

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Geotourism and Climate Change

Paradoxes and Promises of Geotourism in Polar Regions

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ABSTRACT: Geotourism has achieved considerable prominence since the early 1990s as a means of conserving geological and geomorphological heritage. However, most accounts of the effects of geotourism are at a site-specific level while interpretation tends to focus on deep geological time rather than the Anthropocene. This restriction in consideration of time and space has meant that the broader effects of geotourism-related travel throughout the tourism system have been ignored, along with the potential role of climate change in affecting geosites and attractions. These issues are discussed with respect to the paradoxes of geotourism in polar regions with the polar cryospheric environment being both threatened by climate change yet simultaneously becoming more accessible and attractive to tourists. The article concludes that, like any form of tourism, geotourism needs to be understood within the broader context of tourism and physical systems rather than in isolation in order to fully access its contribution to geoconservation.

Key Words: Geotourism, climate change, tourism system, emissions, polar tourism.

Geotourism, tourism and recreational visitation that is related to geology and geomorphology and the associated natural resources of landscapes, landforms, fossils and minerals (Hose, 1996, 2008; Lew, 2002; Newsome et Dowling, 2006; Pralong, 2006), has become a significant conservation and tourism topic since the early 1990s (Gray, 2004; Reynard et Coratza, 2007). However, the majority of research on geotourism, as well as geotourism sites, which are specifically identified geotourism attractions and/or protected areas (geoparks), has tended to focus on locations that represent geological deep time (Hose, 2005) rather than the immediate implications of anthropogenic influence on physical landscape and geomorphology, which operate in contemporary or shallow time (Dowling et Newsome, 2006). In some senses this is quite surprising given that geosites cannot only help contextualise "issues of place in the universe and scheme of life" but can also be used to highlight "some pressing environmental issues, climate change and finite mineral and fuel resource management" (Hose, 2006: 236).

Anthropogenic induced climate change is arguably one of the most significant aspects of the Anthropocene, along with biodiversity loss, biotic transfer, and desertification (Crutzen et Stoermer, 2000). These changes, although likely only in their initial phases, are regarded as sufficiently distinct and robustly established for suggestions of a Holocene—Anthropocene boundary in the recent historical past to be geologically reasonable (Zalasiewicz *et al.*, 2008). Indeed, the rise of CO_2 levels above background levels has been suggested as a specific marker to differentiate the Anthropocene from the Holocene (Crutzen, 2002). That human-related climate change is a serious environmental issue is not beyond doubt. However, climate change is also a geomorphological issue given that, "since the start of the Industrial Revolution, Earth has endured changes sufficient to leave a global stratigraphic signature distinct from that of the Holocene or of previous Pleistocene interglacial phases, encompassing novel biotic, sedimentary, and geochemical change" (Zalasiewicz *et al.*, 2008: 4). It is also important to note that many of the tools employed to understand geological, geomorphological and landscape processes are the same ones being used to identify the role of climate change in the Earth's physical and human systems. Yet, despite the role of geotourism in promoting conservation at geosites and geoparks, there has been a general failure of the concept to incorporate an understanding of the tourism system-wide

Table 1 : **Summary of IPCC findings with respect to climate change in the polar regions**

	Confidence* level			
	Low	Medium	High	Very high
Both polar regions				
Strong evidence of the ongoing impacts of climate change on terrestrial and freshwater species, communities and ecosystems				X
- that such changes will continue			X	
- with implications for biological resources and globally important feedbacks to climate		X		
Surface albedo is projected to decrease and the exchange of greenhouse gases between polar landscapes and the atmosphere will change				X
Components of the terrestrial cryosphere and hydrology are increasingly being affected by climate change				X
- these changes will have cascading effects on key regional bio-physical systems and cause global climatic feedbacks, and in the north will affect socio-economic systems			X	
Changes to cryospheric processes are modifying seasonal runoff and routings				X
Continued changes in sea-ice extent, warming and acidification of the polar oceans are likely to further impact the biomass and community composition of marine biota as well as human activities			X	
Acidification of polar waters is predicted to have adverse effects on calcified organisms and consequential effects on species that rely upon them			X	
Arctic				
Strong evidence exists of changes in species' ranges and abundances and in the position of some tree lines			X	
Increase in greenness and biological productivity has occurred in parts			X	
A small net accumulation of carbon will occur in Arctic tundra during the present century	X			
Higher methane emissions responding to the thawing of permafrost and an overall increase in wetlands will enhance radiative forcing		X		
Increased Eurasian river discharge to the Arctic Ocean, and continued declines in the ice volume of Arctic and sub-Arctic glaciers and the Greenland ice sheet				X
Combined effects of changes to cryospheric and hydrological processes will impact freshwater, riparian and near-shore marine systems			X	
Economic benefits, such as enhanced hydropower potential, may accrue, but some livelihoods are likely to be adversely affected			X	

(Continues)

effects of contemporary climate change into geotourism and geoconservation management and principles.

The purpose of this article is to discuss some of the issues raised by human induced climate change for geotourism and highlight some of the paradoxes and problems it presents as well as some distinct management issues. It does this with specific reference to tourism in polar regions which are areas of major importance in terms of both geotourism, as a result of the attractiveness of polar environments, and climate change, being the part of the planet that has witnessed the most rapid environmental change as a result of climate change (Anisimov, 2007).

Polar landscapes and climate change

As territories or locations, the polar regions can be defined in different ways (Hall et Saarinen, 2010a, 2010b). Geographical markers of the polar regions include latitude and longitude, biophysical boundaries and political boundaries. The Antarctic is usually defined as south of 60°S latitude (the definition used in the 1959 Antarctic Treaty) that includes the continent of Antarctic and its ice shelves, as well as the waters and island territories in the Southern Ocean, or the continent of Antarctica. Another common delineation of the region includes the area south of the Antarctic convergence, which is an important climatic boundary between air and water masses, and is also used as the approximate boundary of the Southern Ocean that surrounds the Antarctic continent. However, for the purposes of this paper the former definition of the Antarctic is used, while the term sub-Antarctic is ascribed to the islands in the Insulantarctic biogeographical province and the islands south of New Zealand (Udvardy, 1987).

Various delineations of the Arctic also exist, the most common are based on indicators of phytogeography (e.g. the treeline), climate (e.g. the July 10° isotherm), geomorphology (permafrost) or solely on latitude (e.g. north of the Arctic Circle at 66°33'N or 60°N) (Hall et Saarinen, 2010b). However, the Arctic area extends even further geographically if a bioregional approach is used, i.e. by including the watersheds of the rivers that drain into the Arctic Ocean, or if political regions are utilised, i.e. including provincial and national jurisdictions. For example, in the case of the Arctic Council's (2004) *Arctic Human Development Report* (AHDR), the region

Table 1 : **Summary of IPCC findings with respect to climate change in the polar regions** (Continued)

	Confidence* level			
	Low	Medium	High	Very high
Adaptation will be required to maintain freshwater transportation networks with the loss of ice cover			X	
Impact of climate change on Arctic fisheries will be regionally specific; some beneficial and some detrimental. The reduction of Arctic sea ice has led to improved marine access, increased coastal wave action, changes in coastal ecology/biological production and adverse effects on ice-dependent marine wildlife, and continued loss of Arctic sea ice will have human costs and benefits			X	
Human communities are adapting to climate change, but both external and internal stressors challenge their adaptive capabilities			X	
Benefits associated with climate change will be regionally specific and widely variable at different locations		X		
Impacts on food accessibility and availability, and personal safety are leading to changes in resource and wildlife management and in livelihoods of individuals (e.g., hunting, traveling)			X	
The resilience shown historically by Arctic indigenous peoples is now being severely tested			X	
Warming and thawing of permafrost will bring detrimental impacts on community infrastructure			X	
Substantial investments will be needed to adapt or relocate physical structures and communities			X	
The benefits of a less severe climate are dependant on local conditions, but include reduced heating costs, increasing agricultural and forestry opportunities, more navigable northern sea routes, and marine access to resources		X		
Antarctic				
Some parts of the Antarctic ice sheet are losing significant volume				X
Combined effects of changes to cryospheric and hydrological processes will impact freshwater, riparian and near-shore marine systems on sub-Antarctic islands			X	
Further decline of sea-ice extent will impact the predators and ecosystems of krill			X	

Source: derived from Ansimov *et al.* (2007).

*** Description of confidence (IPCC 2007: 4):**

Terminology	*Degree of confidence in being correct*
Very high confidence	At least 9 out of 10 chance
High confidence	About 8 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than a 1 out of 10 chance

covered a number of areas below 60°N in Canada (southern Nunavik), the USA (parts of Alaska including the Aleutian Islands) and Russia (parts of Kamchatka, Magadan and Sakha (Yakutia) Republic). Such an approach, which has also been adopted in a number of scientific surveys of the region (CAFF International Secretariat, 2010; Forbes *et al.*, 2010; Hall et Saarinen, 2010c), provides the basis of the definition of the Arctic used in this paper.

The 2007 Intergovernmental Panel on Climate Change (IPCC) report provides a benchmark from which to evaluate the potential implications of climate change for polar regions and for tourism. Table 1 provides a summary of IPCC findings with respect to climate change in the polar regions (Anisimov *et al.*, 2007). The IPCC has highlighted the extent to which sub-regions of the Arctic (the interior portions of northern Asia and north-western North America) and Antarctic (the Antarctic Peninsula) demonstrated the most rapid rates of warming over the last century (Turner *et al.*, 2007).

Serreze and Francis (2006) concluded that the Arctic is manifesting the early stages of a human-induced greenhouse signature. Surface air temperatures in the Arctic have warmed at approximately twice the global rate (McBean *et al.*, 2005), with a figure of 1-2°C representing the areally averaged warming north of 60°N since a temperature minimum in the 1960s and 1970s. The most recent (1980 to present) warming of much of the Arctic is greatest (about 1°C/decade) in winter and spring, and weakest in autumn; it is strongest over the interior portions of northern Asia and north-western North America (McBean *et al.*, 2005). The extent of recent warming is such that it has been recognized as the warmest period in the Arctic for the last 2,000 years with four of the five warmest decades in that period occurring in the past 50 years (Kaufman *et al.*, 2009). Precipitation in the Arctic has increased at about one percent per decade over the past century, although the trends are spatially highly variable and highly uncertain because of deficiencies in the meteorological record (McBean *et al.*, 2005).

The extent of Arctic sea ice has reduced substantially since the 1950s and there is no indication that the long-term trends are reversing (Schiermeier, 2009). Sea ice in the Arctic shrank to its smallest size on record in September 2007, when it extended across an area of just 4.13 million km^2, beating the previous low of 5.32 million km^2, measured in 2005 (Giles *et al.*, 2008). Using previously classified submarine data, Kwok and Rothrock (2009) indicate that the average thickness at the end of the melt season has decreased by 1.6m or some 53 per cent from 1958 to 2008.

It is important to stress that in terms of physical processes such changes are interrelated. For example, in the case of the decline of Arctic sea-ice cover (NSIDC, 2009), less ice means more open water exposed to shortwave solar radiation that is absorbed and transformed into heat. This provides a strong positive feedback that further accelerates the melting of sea ice (Sea-ice areas covered with snow have a high albedo that reflects 80 per cent of the incoming solar radiation back into space; in contrast, the open ocean has a low albedo that reflects only 20 per cent of solar radiation, absorbing the other 80 per cent) (Dmitrenko *et al.*, 2008; Dickson, 2009). Such a situation led to a group of scientists associated with the International Polar Year (IPY) (2009) to conclude "that there is a very low probability that Arctic sea ice will ever recover… The entire Arctic system is evolving to a new super interglacial stage seasonally ice free, and this will have profound consequences for all the elements of the Arctic cryosphere, marine and terrestrial ecosystems and human activities".

The loss of Arctic sea ice cover means that it is not just the ocean that is subject to change but that it is severely affecting the coastline and hinterland. The larger heat transfer from the ocean to the atmosphere—the maritime effect—will help moderate autumn and winter cold temperatures. As ice retreats from shorelines, "winds gain a longer fetch over open water, resulting in stronger waves and increased shore erosion. The rapid retreat of Arctic sea ice could accelerate rapid warming 1,500 km inland throughout Alaska, Canada, and Russia. During rapid ice retreat, the rate of inland warming could be more than three times that previously suggested by global climate models" (McMullen et Jabbour, 2009: 19).

All meteorological stations on the Antarctic Peninsula also show strong and significant warming since the 1950s with the peninsula becoming a focus of media attention to global climate change. However, over the wider Antarctic there is considerable variability in temperature trends. Anisimov *et al.* (2007) noted that if the individual station records are considered as independent measurements, then the mean trend is warming at a rate comparable to mean global warming (Vaughan *et al.*, 2003), but observed that there is no evidence of a continent-wide 'polar amplification' in Antarctica. Since 1978 (from when satellite data provided reliable data), there is been no general trend in duration of Antarctic sea-ice, but there has been strong regional trends with duration increasing in the Ross Sea and decreasing in the Amundsen and Bellingshausen Seas (Parkinson, 2002). Such patterns strongly reflect trends in atmospheric temperatures in those regions (Vaughn *et al.*, 2003). Walsh (2009) notes that the ongoing climate variations in the Arctic and Antarctic pose an apparent paradox with the fact that Antarctic temperatures and sea ice show little change, except for the Antarctic Peninsula, being in stark contrast to the large warming and loss of sea ice in the Arctic. Nevertheless, de la Mere (2009) argues that there can be little doubt that a substantial shift in the extent of sea ice occurred from the 1930s to the 1980s, which corresponded to a 20 to 30 per cent reduction in sea ice. In both the Arctic and Antarctic, the effects of climate change not only have raised public interest in these regions but have also served to make the areas more accessible. Yet increased access and tourism to the regions to see the polar landscapes may also contribute to further environmental change.

Polar geotourism and environmental change

Climatic conditions are extremely important for tourism because of the extent to which they influence the relative accessibility and attractiveness of a given location (UNWTO-UNEP-WMO, 2008). Climate change influences the seasonality of a tourism location or attraction because of the extent to which access is economically and geographically feasible in a polar environment, as well as determining the local environmental conditions that may prove appealing to visitors. For example, climate change is regarded as having enabled the lengthening of the northern polar cruise season as well as providing access to hitherto inaccessible locations (Hall, James et Wilson, 2010; Hall et Saarinen, 2010a). Indeed, there is potentially something of a paradox given that while tourism is a significant contributor to climate change (UNWTO-UNEP-WMO, 2008), it is also a beneficiary because greater access is now possible for tourists to some polar areas as a result of reduced sea ice and warmer weather.

Although species, such as polar bears, penguins and whales, are significant icons for polar tourism, the polar cryospheric landscape and geology as well as specific geosites, such as scientific reserves and national parks that have been established to protect geological and landscape heritage values, are integral to its attractiveness for tourism. For instance, geological features such as glaciers and glacial landscapes, permafrost landforms, sea ice, icebergs, cryospheric geomorphology, and even hot springs are featured on many tour itineraries and are often highly romanticised with respect to being part of one of the world's last wilderness areas (Pringle, 1991). Yet the 'wild' image of polar landscapes is also increasingly combined with the idea of 'threat' as a result of climate and other forms of change (Hall et Saarinen, 2010a). For example, from 2007 to 2009, a number of notable weather anomalies occurred, with each receiving considerable publicity in the international media including Alaska having its second highest winter snowfall in 30 years in 2007-2008; the Northern Hemisphere having its largest January snow cover extent on record in 2008; Arctic Sea Ice reaching its all-time lowest extent on record in September 2007; the warmest winter ever recorded in most parts of Norway, Sweden and Finland in 2008; and also in 2008 Eurasian Snow Cover having the largest January extent on record and smallest extent during March, April, and boreal spring (McMullen et Jabbour, 2009). The role of climate change in polar environments is also compounded by its interaction with other anthropogenic pressures including industrial activities and development, pollution, biodiversity loss, and the introduction of invasive species (CAFF International Secretariat, 2010; Hall *et al.*, 2010).

The growing public awareness of the polar regions at being at great risk of environmental change is therefore introducing a new set of real and imagined high latitude geographies in which the Arctic and Antarctic, rather than being portrayed as remote areas of high risk, are increasingly being seen as fragile and 'at risk' environments (Hall et Saarinen, 2010a). The historical place of the polar regions in the imagination as an icy wilderness is therefore being inverted (Pyne, 1986; Pringle, 1991). The changing and cumulative perceptions of the Arctic and Antarctic comprise what Sörlin (1999) describes as the "articulation of territory". Which can be understood as the way in which the physical cryospheric landscapes also become symbolic and mental landscapes that are deeply embedded in the image and self-understanding of nations, regions and individuals. Such articulations serve as major drivers for geotourism, creating images of landscape and place in the minds of consumers as well as providing motivations for travel. Even those polar activities labeled as adventure tourism, heritage tourism and special interest tourism have a strong landscape component that overlaps with broad interpretations of geotourism (Gray, 2004; Hose, 2005; Hall et Saarinen, 2010c). It is therefore perhaps not surprising that contemporary environmental change is providing a new set of drivers and promotional possibilities for polar tourism. For example, government agencies, such as the Alaskan Office of Economic Development (2008), publicly state that climate change is an opportunity for tourism as "Global warming or climate change, and the impacts on Alaska—puts Alaska in the spotlight" (2008: 34). Similarly, the front cover of the March 2008 issue of Destinations of the World News (2008) was entitled "The Arctic Tourism's disappearing world" and contained a series of articles on "paradise lost "with Round (2008: 46) stating:

> The wild wonder of the Arctic is one of the hottest destinations of the world. As climate change fuels larger visitor numbers and the cruise industry booms, the race to the top of the world is getting more intense.
>
> The Arctic has got to be one of the most fashionable destinations of the world. Any style magazine worth its weight in off-the-beaten path travel features is featuring the region as this year's must see.
>
> Adding further impetus to Arctic travel are numerous documentaries, websites, pressure groups, photographers and journalists all charting the slow meltdown of global warming led by photogenic polar bears swimming for miles for food and glaciers dramatically cracking into the sea.
>
> The plight of the region has become such a part of our contemporary background that it's no wonder demand for the region has become so high.

More recently Mads Nordlund of Greenland's Tourism and Business Council has told the same magazine a similar story, "Greenland is always featured in those books that offer 100 Places To Visit Before They Disappear… It's like Kilimanjaro, you can see the change taking place. People want to see it before the ice goes" (in Round, 2009). Given such concerns, it is perhaps not surprising that some polar destinations and tourism companies are looking to promote climate change tourism (Hall et Saarinen, 2010) as part of a 'Last chance to see' also referred to as "doom tourism" (UK MSN Travel, 2009). "The world has never traveled to the Arctic like now. Aided by global warming—that's opening up areas never before visited—but tinged by a quiet urgency, it's here the world gets a live demonstration of how our world is changing" (Destinations of the World News, 2008: 2). Round's (2008: 46) observation noted above that, "The message is quite clear: come quickly or you'll miss it", is something of a moot point, but it is one clearly shared by a number of travel writers and commentators (E The Environmental Magazine, 2002; Egan, 2005; Margolis, 2006; Hall, 2009; Hall et Saarinen, 2010d; Lemelin *et al.*, 2010).

The promotion of geotourism attractions by the tourism industry, especially with respect to the rapidly changing polar landscape and geology, may potentially be at odds with the scientific goals of conserving significant geoheritage (Gray, 2004; Reynard et Coratza, 2007; Hall *et al.*, 2010). Science often tends to intrinsically value geodiversity, as well as recognize aesthetic and cultural values, whereas tourism operations and marketing promotes an utilitarian dimension that economically commodifies other value sets. Moreover, justification for geosite conservation by park and reserve designation is often based on the assumption that they will attract tourists (Hose, 1996; Dowling et Newsome, 2006). The potential conflict between scientific and economic goals in geotourism promotion is therefore symptomatic of the broader demands for both conservation and use in many national parks and reserves (Frost et Hall, 2008). Direct visitor impacts on geoconservation sites "may result in loss of, or damage to, important rocks, minerals, or fossils, remodelling of natural topography, loss of access or visibility, interruption of natural processes, pollution, or visual impacts" (Gray, 2005: 9). Traditional scientific concern for geoconservation has focused on ways to manage impacts via site-specific mechanisms such as changes to public access, site hardening, and interpretation (Gray, 2004, 2005; Dowling et Newsome, 2006). However, as the next section discusses, the impacts of geotourism in the broader polar context should also allow greater consideration of the system-wide contribution of tourism to cryospheric environmental change and other changes to geodiversity.

The impacts of polar geotourism

As Hall and Saarinen (2010a, 2010b) highlight, the numbers of tourists traveling in the Arctic region is substantial, of the order of over five million visitors per year. Such figures run counter to the perspectives of Frigg Jorgensen, general secretary of the Arctic Expedition Cruise Operators (AECO) who commented,

> Passengers are usually highly educated people that understand the importance of conservation. Secondly, our regulations and those of Arctic countries protect sites. Thirdly, operators are responsible for managing them properly and it's in their interests to maintain the pristine environment they are selling. Finally, compared to national parks in Alaska where many thousands visit, for example, the number of Arctic tourists [is] minimal (quoted in Round, 2008: 47).

Similarly, Round (2008: 46) states, "do we need just a little more perspective? Only a few thousand travelers visit the Arctic every year compared to the hundreds of thousands of people that cross the manicured grass of New York's Central Park everyday". Apart from the geographical challenge of not including Alaska as part of the Arctic, there still remains the issue that the number of tourists is continuing to grow and represents a significant figure in relation to permanent populations and are concentrated in a small number of accessible areas in space and time. For example, the number of fly-in tourists per year to Greenland now exceeds its permanent population, with the number of cruise guests already being over half. A similar situation with respect to number of visitors per year in relation to permanent population also exists in Iceland, Svalbard, and northern Norway, Sweden and Finland above the Arctic Circle (Hall et Saarinen, 2010a, 2010b). Although the tourist numbers for the Arctic would appear to be low if they were calculated on a tourist per square kilometer basis (approximately one tourist per 3 km^2), the reality is that sites of permanent settlement and tourist accommodation, attraction and transport hubs are usually co-located and therefore increases in visitor arrivals can place significant pressure on permanent infrastructure.

Given the growing number of visitors to the Arctic tourism is regarded as a key component of the economy. Climate change, rather than having a negative impact on the regional economy is often regarded as being a major beneficiary along with maritime transport, generally as access to many northern areas is improved (Arctic Climate Impacts Assessment (ACIA), 2005). Similarly, Antarctica and the sub-Antarctic are also receiving increasing numbers of tourists, which although not on the scale of the Arctic, also has significant economic benefits both for the small number of sub-Antarctic communities as well as gateway communities in Australia, New Zealand and South America (Hall 2000; Hall et Wilson, 2010). And, given the much smaller amount of visitor access to ice-free areas, tourism is arguably of proportionally even greater significance in terms of direct environmental impact in the Antarctic than the Arctic (Hall, 2010a).

The polar areas therefore highlight the paradoxes and complexities that geotourism can present. While geotourism can potentially contribute to employment generation, sustainable improvement of infrastructure and geological and geomorphological conservation (El Wartiti *et al.*, 2009), it is vital that the impacts of geotourism be fully assessed at all scales (Hall, 2007). Therefore, in the context of understanding the contribution of geotourism to environmental change, it becomes important to go beyond analysis at the level of a geosite, "a site or an 'area', a few square meters to several square kilometers in size, with geological and scientific significance, whose geological characteristics (mineral, structural, geomorphological, physiographic) meet one or several criteria for classifying it as outstanding (valuable, rare, vulnerable, endangered)" (El Wartiti *et al.*, 2009: 143). In the case of geotourism, as with other forms of tourism, consideration of impacts only at the site level fail to account for the effects of the travel of tourists to and from such sites, of which emissions will be of particular importance given their broader contribution to climate and environmental change.

The emissions contribution of geotourism-related travel to polar regions may be substantial. At a regional level the relative contribution of tourism to greenhouse gas (GHG) emissions in polar regions is likely greater than for many other regions because of the reliance on aviation and cruise ships. For example, in examining the emissions from Antarctic tourism in the 2004/2005 Austral Summer season, Amelung and Lamers (2007) reported that the average per capita emissions from traveling to the gateway ports of Ushuaia/Punta Arenas and Christchurch by Antarctic bound tourists were 8.58 and 8.48 tonnes per capita respectively. Total ship-based CO_2 emissions were estimated at 169,666 tonnes. Average per capita emissions were 6.16 tonnes per passenger but the contribution varied widely depending on the ship, ranging from 2.09 tonnes per passenger for the *Alexander Humboldt* to 22.63 tonnes per passenger for the *Spirit of Enderby*. The per capita emissions of land-based tourism in Antarctica were estimated as being just under 50 tonnes per tourist, including transport between gateway cities and Antarctica. Cruising provides the largest single source of direct CO_2 emissions although aviation is most important in terms of radiative forcing as a result of non-carbon effects and contributes almost 60 per cent of emissions when calculated in CO_2-equivalents (Lamers, 2009). From their research, Amelung and Lamers (2007) estimated that the total contribution of Antarctic tourism to greenhouse gas emissions for 2004/2005 was 425 ktons of CO_2-equivalents (CO_2-e per person). In absolute terms such an amount is negligible. However, on a per capita basis the 14.97 tonnes of GHG produced during the typical two-week travels of the Antarctic tourist is equal to the total emissions that the average European produces in 17 months.

No comprehensive studies have been conducted of the GHG emissions associated with tourism in northern polar regions. However, the scale of Arctic tourism is substantial and growing, with air and cruise ship the dominant modes of travel to Alaska (over 90 per cent of all visitors), Northwest Territories, Nunavut, Greenland, Iceland, and Svalbard (Hall *et al.*, 2010; Hall et Saarinen, 2010a, 2010b). Even in mainland Arctic Europe, the contribution of aviation to international tourist arrivals is substantial. For example, it is estimated that over half of Finnish Lapland's international tourist arrivals come by air (Halpern, 2008). Although focused primarily on biotic attractions rather than geomorphology, Dawson *et al.* (2010) calculated that the emissions of tourists participating in a polar bear viewing experience in Churchill, Manitoba, range from 1.54-8.61 t/CO_2-e per person. This means that the emissions derived from a polar bear viewing experience is 6 to 34 times higher than the global average for a tourist trip, depending on the distance flown between an individual's place of residence and Churchill. Such figures are significant as they are comparable to the type of remote geotourism experiences that many communities in Alaska and northern Canada seek to promote (Boley et Nickerson, 2009).

Cruiseships can be a major source of GHG emissions at destinations in which the sea provides major access points. This is an extremely important point for the developing cruise operations in Greenland, Svalbard and the Canadian High Arctic. Glacier Bay National Park in Alaska, which is a major geotourism attraction (Gray, 2005), is a focal point for the relationship between geotourism and climate change as a

Table 2: **Glacier Bay National Park and Preserves's greenhouse gas emissions (tonnes) by source and emitting entity**

Emitting Entity	Stationary Combustion	Highway Vehicles & Non-road Equipment	Wastewater Treatment	Waste	Marine Vessels	Gross Emissions
Park Operations	222	30	1	2	65	320
Visitors	NA	NE	NA	NA	3,179	3,179
Glacier Bay Lodge & Tours	111	6	NA	NA	116	234
Other Concessionaires	NA	NA	NA	NA	1,654	1,654
Cruise Ships	NA	NA	NA	NA	8,360	8,360
Gross Emissions	333	36	1	2	13,375	13,747

Source: Climate Friendly Parks (2005). NE=not estimated NA=not applicable

result of glacier decline. In 2004 Glacier Bay received 353,686 recreational visitors. In that year the park's total GHG emissions were 13,747 t/CO_2-e. As Table 2 demonstrates, marine vessels represent the greatest source of GHG emissions (97 per cent of total), followed by stationary combustion (2 per cent of total). Of marine vessel GHG emissions, 63 per cent (8,360 t/CO_2-e) result from operating cruise ships within park boundaries, visitors entering the park in private marine vessels account for approximately 24 per cent (3,179 t/CO_2-e) of marine vessel GHG emissions, while charter and tour vessels operated by concessionaires other than Glacier Bay Lodge & Tours account for approximately 12 per cent (1,654 t/CO_2-e) of marine vessel GHG emissions (Climate Friendly Parks, 2005).

Arctic cruise tourism appears to be continuing to grow with its expansion being encouraged by the opening up of new cruising areas and extended seasons as a result of climate change. Both ACIA (2005) and Anisimov *et al.* (2007) note the potential economic benefits of reduced sea ice for the lengthening of the ship navigation season and increased marine access, including the opening up of new sea routes along the Northwest Passage and the Northern Sea Route. Northwest Passage cruises are already being regularly promoted by high profile travel companies such as Hapag-Lloyd cruises, Quark Expeditions and Peregrine Adventures. Instanes *et al.* (2005) suggest that by 2050, the Northern Sea Route will have 125 days/yr with less than 75 per cent sea-ice cover, which represents favourable conditions for navigation by ice-strengthened ships. However, while this is regarded as a potentially positive benefit of climate change for some northern communities, the effects of such changes will be substantial for northern cryogenic landscapes and landforms (Slaymaker et Kelly, 2007; Forbes *et al.*, 2010).

Conclusion

Although tourism has been regarded by some as inappropriate in high latitude regions because of the potential environmental and, to an extent in the Arctic, socio-cultural impacts, there is 'increasing recognition that responsible tourism is an appropriate and legitimate activity' (Splettstoesser, 2000: 54). For example, because of the extent to which tourism provides an economic justification for transport infrastructure that existing population sizes may not justify alone, tourism becomes extremely important in providing connectivity for peripheral high-latitude communities to major settlements. This may take the form of increased numbers of connections (i.e. flights), improved connections (i.e better quality of road, or speed of transport available), or whether there is a connection or not at all. Tourism's role in polar economic development when well planned and managed therefore goes well beyond that of tourism alone as it provides a major 'enabling' role via transport, accommodation and other infrastructure that may also contribute to local quality of life. Nevertheless, the environmental costs of transport do need to be considered in any assessment of its overall contribution to Arctic development. Indeed, Hall *et al.* (2010) identified that a large majority of the cruise companies that operate in the Arctic do not have mandatory carbon offsetting in their product offerings with many not even promoting voluntary schemes. As of 2009, fourteen of the 31 cruise companies operating in Atlantic polar and sub-polar waters operated with a code of conduct with respect to minimising their direct visitor impacts (those that were members of the Association of Arctic Expedition Cruise Operators), while fifteen had a publicly available environmental policy (Hall *et al.*, 2010). The problem with many of these codes, policies and guidelines is that they are focused at a site scale or on specific appropriate behaviours. Although this is undoubtedly significant in a site-specific context with respect to ameliorating the immediate direct environmental impacts of tourism, existing codes of conduct do not adequately deal with the broader issues of tourism-related environmental change including the introduction of biologically invasive species (Hall, 2010b, 2010c; Hall *et al.*, 2010). Given that tourism is such a significant economic activity and, as Stewart et al. (2005: 383) noted even a 'desired industry in some communities,' it is clearly vital that a deeper understanding of the complexity of polar geotourism be achieved in terms that are useful for policy-makers, especially when tourism is also integral to climate and environmental change adaptation and mitigation.

Nevertheless, at the present stage of its development, the geotourism discourse tends to function at a location-specific level when considering its costs and benefits. There is a broad failure to consider its contribution in terms of the full tourism system and particularly the effects of getting to and from geotourism sites. This has therefore meant that geotourism's contribution to greenhouse gas emissions and therefore climate change has not been factored in to a full assessment of the geoconservation potential of tourism. In many locations, such as in the polar regions in which the cryogenic landscape is a key part of its attractiveness, geotourism may therefore be contributing to the loss of some of the landscape and landform features that made it attractive in the first place. But, as noted above, we may also be in a double bind with respect to the polar geotourism—climate change relationship, because climate change is making more northern locations of geological and geomorphological interest accessible to visitors. How the growing numbers of operators and management agencies that have embraced geotourism will respond to the paradoxes of tourism in polar regions is, as yet, unknown, but it is starting to be discussed. When interviewed as to the challenge of climate change for tourism Miriam Geitz, Climate Change Officer, WWF International Arctic Programme, commented

> …the most interesting question is how will tour operators respond to climate change themselves. For instance will they visit new areas as soon as they open up, or will they take charge and forgo those areas—that may be sensitive to visitor pressure—to protect them? …Any human activity, not only from tourism, is a stress factor and should be carefully considered for its consequences.
>
> We have seen tourism as the natural ally of nature and local cultures. The people who come to the region come mainly for the experience, and are fairly considerate to preservation. Through their visit, hopefully, they are changed by the experience, connect with the region and become ambassadors to the rest of the world (in Round 2008: 51).

These are also important issues and concerns for those researching polar geotourism and geotourism in general. Tourism, when appropriately planned and managed undoubtedly has much to contribute to polar economies, cultures and science. Yet, Round's (2008: 48) observation with respect to the Greenland and Svalbard Arctic that 'whether you are for or against tourism… there is no doubt that climate change is transforming the region and future visitors will have a very different experience from those of today' will certainly hold true for the polar regions at current rate of change. We certainly do not wish polar geotourism to become 'the last chance to see', yet without appropriate adaptation and mitigation by the tourism industry both globally and at high latitudes, and changes in humankind's unsustainable consumption of natural capital, it is becoming increasingly likely that the polar cryogenic landscapes of today will by the end of this century be but a dim memory retained on film or a tourist DVD. ■

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