Petition to the World Heritage Committee:

The Role of Black Carbon in Endangering World Heritage Sites Threatened by Glacial Melt and Sea Level Rise

January 29, 2009

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Executive Summary

This petition calls on the World Heritage Committee to take action to protect the outstanding universal values of World Heritage Sites most vulnerable to global warming – high latitude and altitude glaciers and low-elevation sites threatened by sea level rise – by advancing strategies to reduce emissions of the global warming pollutant black carbon. Recent scientific studies identify black carbon, a component of fine particulate matter, as a key climate forcing agent, and suggest that reducing these emissions may be among the most effective near-term strategies for slowing the amplified climate warming experienced at high latitudes (i.e., in the Arctic) and altitudes (i.e., mountain glaciers). As glaciers melt, sea levels rise, threatening World Heritage sites with coral reefs and coastal lowlands. Because black carbon is a short-lived climate forcing agent, with an atmospheric lifetime of only days or weeks, reducing emissions has an immediate effect and slows global warming in the near term. This action can help maintain the universal values of vulnerable World Heritage sites. Without action to slow near-term global warming, it may be impossible to protect many World Heritage sites from damage or destruction caused by climate change.

The World Heritage Committee has a unique opportunity to advance critical, early action to reduce black carbon emissions and thus help to preserve World Heritage until the strategies for reducing long-lived greenhouse gas emissions being negotiated by the UNFCCC process can be realized. By placing climate-threatened sites on the List of World Heritage in Danger, and taking action to advance research and mitigation strategies for black carbon sources that threaten Arctic and montane glacial sites, the Committee can assist States Parties to reduce emissions of this pollutant and slow the rate of glacial melt and resulting sea level rise that threaten the outstanding universal values of so many World Heritage sites.

As the World Heritage Committee has recognized, "the impacts of Climate Change are affecting many and are likely to affect many more World Heritage properties, both natural and cultural in the years to come."[1] We know that the effects of climate change are amplified and accelerated at latitude and altitude: the Arctic is warming about twice as fast as the rest of the earth, and the Greenland ice sheet is melting twice as fast as the global mean. The melting of glaciers, including many designated as World Heritage sites, and especially those in the Arctic, is directly linked to sea level rise, which threatens many low-lying parts of the world, including World Heritage sites with coastal wetlands and coral reef ecosystems. Thus, protection of glacial and montane sites is essential not only for the preservation of their characteristics of outstanding universal value, but also for the preservation of many other World Heritage sites around the world.

Recent studies identify black carbon, a component of ultrafine particulate pollution, as a critical climate warming agent both in the atmosphere and when deposited on snow and ice. Black carbon is released into the atmosphere during the inefficient burning of fossil fuels,

[1] World Heritage Committee Decision 30 Com 7.1, WHC-06/30.COM/7.1, (2006).

biofuels, and biomass. It is often transported long distances by air currents. Because the dark-colored particles absorb sunlight, black carbon warms the top of the atmosphere, increasing cloud droplet concentrations, and thickening low-level clouds. When deposited on ice and snow, it reduces the albedo, or reflectivity, of these surfaces, and increases the rate of melting. As these surfaces melt, the darker water or land exposed below absorbs more incoming sunlight, causing additional warming. Black carbon is considered to be the second most powerful contributor to global warming after carbon dioxide, and because of feedback effects on snow, warms the planet three times more than CO_2.

Unlike CO2 and many other greenhouse gases, which contribute to global warming for decades or centuries once in the atmosphere, black carbon is a short-lived forcer, remaining in the atmosphere for days to weeks. Because of this, reducing black carbon emissions can be an effective rapid response to slow warming in the near term, protecting arctic and montane glaciers as well as snow pack and permafrost, and buying critical time to realize reduction in long-lived greenhouse gases like carbon dioxide. Black carbon emissions can be sharply reduced with existing technologies, for example by improving the efficiency of fuel combustion, switching to low sulfur fuel that enables the use of more efficient particle traps on diesel engines; installing pollution control technologies on smokestacks of power plants and industrial facilities; controlling agricultural residue burning, and providing alternatives to biomass burning for cooking and residential heating.

The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, both in their current forms and in the ongoing negotiations for a post-2012 climate agreement, focus on long-lived greenhouse gases (GHG). Achieving deep and rapid reductions in GHG emissions is the fundamental global priority. Nevertheless, if action is not taken in the interim, the outstanding universal values of many World Heritage sites will not survive until these long-term solutions take effect. As an essential complement to deep cuts in greenhouse gases, reducing these short-lived emissions may be among the most effective strategies for slowing global and Arctic warming in the near term, and for averting catastrophic tipping points such as the melting of sea ice and the Greenland ice sheet. Rapid deployment of already available technologies for reducing black carbon emissions is therefore crucial to avoiding catastrophic climate change.

The World Heritage Committee has the opportunity to advance critical, early action on this issue and take important steps to preserve World Heritage until the effects of the UNFCCC process can be realized. Because the causes of climate change are inherently transboundary, and because the impacts of climate change on such World Heritage sites as the Ilulissat Glacier in Greenland could trigger catastrophic tipping points that would accelerate damage to other diverse sites around the world, protection of World Heritage requires new thinking and approaches.

Inscription on the List of World Heritage in Danger is a useful tool to identify those sites that are most adversely affected, but coordinated international mitigation and adaptation action is also essential. The Committee should request its Advisory Bodies, State Parties and site managers to undertake studies to determine the sources of black carbon that are polluting various high latitude and altitude sites, and recommend measures that State Parties could take to reduce emissions from these sources. The Committee should also coordinate with other United Nations bodies, as well as air quality regulatory organizations working on climate issues, to ensure that these bodies understand the impacts that climate change and, in particular, black carbon are having on World Heritage sites, and to encourage these bodies to take steps to mitigate the impacts of short-term climate forcers. Finally, the Committee should encourage and fund the transfer of technologies available to State Parties and site managers to mitigate the impacts of black carbon on World Heritage sites.

The focus of this petition – the need to take steps to reduce emissions of the short-term climate forcer, black carbon – distinguishes it from past petitions to list sites due to the general impacts of climate change. Previous petitions and reports have not addressed the global warming impacts of the short-lived pollutant black carbon. As a result, the Committee has been unnecessarily limited in its potential role for actually protecting these sites.

Distinct from the situation of long-lived greenhouse gases, which can remain in the atmosphere for centuries, reducing black carbon emissions has an immediate cooling effect. In other words, reducing black carbon emissions is an effective near-term mitigation measure. This petition requests that the Committee take action that is specific, does not overlap with the work of other international bodies, and falls squarely within the Committee's mandate under the Convention. The Committee has a number of tools at its disposal to address the threats presented by climate change and black carbon. Accordingly, the Petitioners respectfully request that the World Heritage Committee takes the following actions to address the threats that black carbon poses to World Heritage:

- Request the Advisory Bodies, State Parties and site managers to cooperatively undertake studies to determine the sources of black carbon that are polluting various high latitude and altitude sites and recommend measures that State Parties and site managers could take to reduce emissions from these sources;
- Place the World Heritage sites addressed in this petition on the List of World Heritage in Danger and develop, in consultation with the relevant State Parties, a program for corrective measures that incorporates the results of the studies described above;
- Coordinate with other United Nations bodies working on climate issues to educate these bodies and State Parties on the impacts that climate change and, in particular, black carbon, are having on World Heritage sites and to encourage them to take steps to mitigate the impacts of black carbon;
- Encourage and fund the transfer of available technologies to State Parties and site managers to help mitigate the impacts of black carbon emissions on World Heritage sites.

I. Introduction: Black Carbon and its Impact on World Heritage Sites

This petition focuses on black carbon, a short-lived climate forcing pollutant that exacerbates threats to World Heritage sites affected by rapid glacial melt or sea level rise. Without action to slow near-term global warming, it may be impossible to protect many World Heritage sites from damage or destruction caused by climate change.

Short-lived[2] climate-forcing[3] agents include black carbon, a component of soot, as well as methane and tropospheric (ground-level) ozone. All three are significant contributors to global and regional climate warming. Methane is one of the six gases listed under the Kyoto Protocol to the UNFCCC.[4] Tropospheric ozone is not emitted directly but rather is formed by the chemical interaction of sunlight with hydrocarbons, nitrogen oxides, and methane, among other precursors.[5] Black carbon is unique among the three common short-lived forcers in that it is not currently addressed by the UNFCCC and its emissions are amenable to mitigation with existing technologies.

Importantly, reductions of black carbon emissions, like mitigation of methane and tropospheric ozone, slow global warming in the near term, helping to maintain the universal value of World Heritage sites affected by glacial melt or sea level rise, and buying critical time for the implementation of strategies to reduce atmospheric concentrations of long-lived warming agents such as carbon dioxide.[6]

Reduction of emissions of black carbon could help to protect World Heritage sites most vulnerable to global warming, including those with glaciers at high altitudes or latitudes, as well as low-elevation sites threatened by sea level rise. Protecting the environmental integrity of climate-threatened World Heritage sites will also help to mitigate the severe consequences of

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[2] Global atmospheric lifetime is the mass of a gas or particle in the atmosphere divided by the mass that is removed from the atmosphere each year; *see* Levy, H. et al., 2008, Climate Projections Based on Emissions Scenarios for Long-Lived and Short-Lived Radiatively Active Gases and Aerosols, U.S. Climate Change Science Program Synthesis and Assessment Product 3.2, September 2008, at 13.

[3] Short-lived gases and particles of interest to climate studies have lifetimes of about a day to a week for most particles including black carbon, a day for nitrogen oxides, and a week to a month for ozone. As a result of their short lifetimes, their concentrations are highly variable in space and time and are often concentrated in the lowest part of the atmosphere, primarily near their sources. *See* Levy et al. 2008 *supra* note 2 at 13.

[4] The UN Framework Convention on Climate Change covers six greenhouse gases: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6). *See Kyoto Protocol to the United Nations Framework Convention on Climate Change*, Annex A, (1997).

[5] UCAR, Tropospheric Ozone, the Polluter, http://www.ucar.edu/learn/1_7_1.htm, accessed January 23, 2009.

[6] Long-lived gases of interest have atmospheric lifetimes that range from ten years for methane to more than 100 years for nitrous oxide. While carbon dioxide's lifetime is more complex, it can be more than 100 years in the climate system. As a result of their long atmospheric lifetimes, long-lived gases are well mixed and evenly distributed throughout the lower atmosphere, and their concentrations change slowly with time. *See* Levy et al. 2008 *supra* note 2 at 13.

climate change for nearby and downstream human populations, including those living in vulnerable low-lying areas. Protecting glacial World Heritage sites could also reduce the potentially catastrophic impacts of glacier retreat, including flooding followed by reductions in drinking and irrigation water supply (and thus food security) for hundreds of millions of people.

Anthropogenic climate change is inherently a transboundary issue. Greenhouse gases and climate-forcing pollutants like black carbon are transported from sources of emissions across national and continental boundaries by atmospheric currents. Although black carbon remains aloft for only days to weeks, it can circulate from the equator to the poles before being deposited by precipitation.[7] In its *Policy Document on the Impacts of Climate Change on World Heritage Properties*, the World Heritage Committee acknowledges that threats to World Heritage sites and factors that may cause a site's inclusion on the List of World Heritage in Danger may be beyond the control of the State Party concerned.[8] The Committee has also acknowledged that climatic threats to World Heritage sites are global and transboundary in nature and are thus distinct from the kinds of threats that can be resolved by national action alone.[9] Protecting World Heritage sites from the most severe impacts of climate change requires international cooperation.

The Committee has a unique role to play in assisting States Parties to begin to address mitigation of this pollutant that threatens World Heritage sites both within and beyond their borders. Coordinated research and action can have an immediate impact to reduce the rate of glacial melt and resulting sea level rise that threaten the outstanding universal value of so many sites. The Committee should take rapid action to advance research and mitigation strategies for black carbon sources that threaten Arctic and montane glacial sites.

II. Black Carbon's Climate Warming Impacts and Mitigation Strategies

A. Black Carbon Is a Potent Climate Forcing Agent in the Atmosphere and when Deposited on Ice and Snow

Black carbon, an aerosol-sized component of soot, is a combustion by-product created from the inefficient burning of fossil fuels, biofuels, and biomass.[10] It is released into the atmosphere as fine particulate matter. The direct absorption of sunlight by black carbon particulates heats the atmosphere. Indirectly, this increases cloud droplet concentrations and thickens low-level clouds that trap the Earth's radiated heat.[11] Heating by black carbon warms

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[7] Zender, C. S., Arctic Climate Effects of Black Carbon, Testimony to the Oversight and Government Reform Committee, United States House of Representatives, October 17, 2007.
[8] UNESCO World Heritage Centre, Policy Document on the Impacts of Climate Change on World Heritage Properties, 2008.
[9] UNESCO World Heritage Centre, Case Studies on Climate Change and World Heritage, 2007.
[10] Ramanathan, V., Role of Black Carbon on Global and Regional climate change, Testimony to the House Committee on Oversight and Government Reform Committee, October 18, 2007.
[11] Id.

the atmosphere from two to six kilometers in altitude, which is where most montane and tropical glaciers are located.[12] Black carbon aerosols stay aloft in the atmosphere for an average of only 4.6 days, and rarely more than a week.[13]

Recent research published since the publication of the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report of 2007 indicates that black carbon is the second most powerful contributor to global warming after carbon dioxide,[14] warming the planet three times more than CO_2.[15] At the top of the atmosphere, black carbon's radiative forcing is as much as 60 percent of the forcing due to CO_2.[16] James Hansen of the U.S. National Aeronautics and Space Administration (NASA) has estimated that the "soot effect on snow albedo may be responsible for a quarter of observed global warming."[17] This is a significant fraction of Arctic warming, which is happening twice as fast as the rest of the earth.[18]

Black carbon is the dominant light-absorbing agent of atmospheric brown clouds, which are composed of black carbon as well as sulfates, nitrates, fly ash, organic acids, and dust.[19] ABCs have been connected to climate and precipitation perturbations around the globe,[20] as they enhance scattering and absorption of solar radiation and produce brighter clouds that are less efficient at releasing precipitation. The climate dynamics of ABCs are significant contributors to glacial melt, surface dimming, increase in atmospheric solar heating, changes in atmospheric thermal structure, atmospheric warming, disruption of regional monsoon patterns, and suppression of rainfall, among other perturbations.[21] Because of these effects, atmospheric brown clouds threaten health and food production for half the world's population.[22]

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[12] Ramanathan, V. and Y. Feng, Air pollution, greenhouse gases and climate change: Global and regional perspectives, Atmospheric Environment, 43, 37-50, doi:10.1016/j.atmosenv.2008.09.063, 2009.
[13] Reddy, M. S. and O. Boucher, Climate impact of black carbon emitted from energy consumption in the world's regions, Geophysical Research Letters, 34, L11802, 2007.
[14] Ramanathan 2007 *supra* note 10.
[15] Flanner, M. G., C. S. Zender, J. T. Randerson, and P. J. Rasch, Present-day climate forcing and response from black carbon in snow, J. Geophys. Res., 112, D11,202, 2007.
[16] Ramanathan 2007 *supra* note 10.
[17] Hansen, J & L. Nazarenko, Soot Climate Forcing Via Snow and Ice Albedos, 101 Proc. Of the Nat'l Acad. Of Sci. 423, 13 January 2004.
[18] Zender 2007 *supra* note 7.
[19] Ramanathan and Carmichael, Global and regional climate changes due to black carbon, Nature Geoscience 1, 2008.
[20] *See, for example*, Levy, H. et al., 2008, *supra* note 2.
[21] Ramanathan 2007 *supra* note 10.
[22] UNEP, Atmospheric Brown Clouds, Regional Assessment Report with Focus on Asia, 2008.

Black carbon is also a potent climate warming agent when deposited on snow and ice.[23] Once deposited, black carbon reduces the albedo, or reflectivity, of these surfaces, and increases the rate of melting, even when air temperatures are below freezing.[24] When these surfaces melt, the darker water or land exposed below absorbs more incoming sunlight, causing additional warming.[25] About half the warming effect of black carbon on snow comes from its dark color, and the other half of its warming effect comes indirectly from exposing the underlying darker earth.[26] This is an example of a positive feedback, or a feedback loop system in which a system responds to an alteration in the same direction as the alteration.[27] Recent studies show that this effect of black carbon is much greater than had been previously assumed. Black carbon on snow during spring melt in the Tibetan Plateau, for example, creates forcing rates 200 times higher than was assumed for black carbon on snow in the IPCC Fourth Assessment Report.[28]

Black carbon is having a significant melting effect on glaciers of the Arctic, including the Greenland ice sheet, as well as on montane glaciers in the Himalayas and other high elevation regions.[29] Over 80 percent of the forcing caused by black carbon on snow comes from black carbon from anthropogenic sources.[30] As black carbon increases melting on the surfaces of glaciers, the resulting meltwater percolates down through cracks in the ice and may increase lubrication at the bottom of the glacier causing the glacier to flow more quickly.[31] This is another example of positive feedback loop for black carbon's climate impacts, as the downward movement of ice to lower (and warmer) altitudes increases its melt rate.[32] Ice sheets calving into the relatively warmer ocean also increase melting.[33] Black carbon deposition increases surface melt on ice masses, and the meltwater spurs multiple radiative and dynamic feedback processes that accelerate ice disintegration.[34] Over the course of the Arctic spring, black carbon-contaminated snow absorbs enough extra sunlight to melt earlier – weeks earlier in some places

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[23] Quinn, P. K., et al., Short-lived pollutants in the Arctic: Their climate impact and possible mitigation strategies, Atmospheric Chemistry and Physics, 8, 1723-1735 (2008); see also Jacobson, M., Testimony for the Hearing on Black Carbon and Arctic, House Committee on Oversight and Government Reform United States House of Representatives, Oct. 18, 2007; Ramanathan, V. & Carmichael, G. 2008 *supra* note 19, and Zender 2007 *supra* note 7.
[24] Flanner et al 2007 *supra* note 15.
[25] Streets, D. G., Dissecting future aerosol emissions: warming tendencies and mitigation opportunities, Climatic Change, 81:313–330DOI 10.1007/s10584-006-9112-8 (2007). See also Ramanathan and Carmichael 2008 *supra* note 2; Quinn et al., 2008 *supra* note and Zender, 2007; and Jacobson, 2007 *supra* note 2.
[26] Qian, Y., et al., Effects of soot-induced snow albedo change on snowpack and hydrological cycle in western U.S. based on WRF chemistry and regional climate simulations, Journal of Geophysical Research- Atmospheres, 2009.
[27] Lenton, T.M., et al., Tipping Elements in the Earth's Climate System, PNAS, vol. 105, no. 6, February 12, 2008.
[28] Flanner et al 2007 *supra* note 15.
[29] UNEP 2008 *supra* note 22; *see also* Reddy, M. S. and O. Boucher 2007 *supra* note 13; *see also* Ramanathan and Feng 2009 *supra* note 12; see also Zender (2007) *supra* note 7.
[30] Flanner et al. 2007 *supra* note 15.
[31] Rignot, Eric, Glaciological studies of the evolution of ice sheets in a warming climate. Eos. Trans. American Geophysical Union, 89 (53), Fall Meeting Suppl., Abstract; *see also* Rignot and Kanagaratnam. "Changes in the Velocity Structure of the Greenland Ice Sheet". *Science* 311: 986, 2006.
[32] Id.
[33] Id.
[34] Hansen, J. and L. Nazarenko 2004 *supra* note 17.

– than clean snow.[35] Another feedback effect that exacerbates glacial retreat occurs when aerosols in atmospheric brown clouds, including black carbon, reduce precipitation downstream from polluted sites. Thus, black carbon increases surface melting of snow, atmospheric temperature, and glacial slide to lower elevations, as well as reducing precipitation over affected glaciers.[36]

The velocities of several large glaciers draining the Greenland ice sheet to the sea have recently doubled to reach 12 km per year.[37] As these glaciers move out to sea, contact with warmer ocean water causes additional melting, at the rate of an increase of 1 meter of ice sheet melt per year for every 0.10^{o}C of ocean warming.[38] Several of the "floating tongues" or ice shelves of outlet glaciers in Greenland have doubled their flow rates since 2000, and the ice sheet experienced a greater surface area of melting in 2006 than at any time since monitoring began in 1979.[39]

Ice core records of black carbon deposition over Greenland from the early nineteenth century onwards provide a historical record for examining the role of black carbon forcing on the retreat of sea ice.[40] In Greenland, precipitation trends have not changed much in the past 400 years, but melting has increased dramatically.[41] Because precipitation is not expected to vastly increase, the result is net shrinkage of the Greenland glaciers.[42] Deposition of black carbon on snow and ice causes the melting that exposes the darker debris-laden ice earlier in the summer season, which could be a significant cause of ongoing thinning of the Greenland ice sheet margin.[43]

In another study, black carbon on snow in the Cascades and Rocky Mountains of the United States was found to warm the snow and air above it by up to 1.2 degrees Fahrenheit, resulting in a thinner snowpack that reflects less light, which further warms the area. This causes regional changes to snowpack that result in dirty snow melting weeks earlier in spring than pristine snow.[44]

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[35] Zender, 2007, *supra* note 7.
[36] Barnett, T.P., J.C. Adam & D.P. Lettenmaier, Potential Impacts of a warming climate on water availability in snow-dominated regions. Nature, v. 338, 17 November 2005.
[37] Dowdeswell, J. A, The Greenland Ice Sheet and Global Sea Level Rise, Science v. 311 at 963, February 17, 2006.
[38] Rignot 2008 *supra* note 31.
[39] Dowdeswell 2006 *supra* note 37; *see also* Lenton, T, H. Held, E. Kriegler, J. W. Hall, W. Lucht., S. Rahmstorf and H. J. Schellnhuber, Tipping Elements in the Earth's Climate System, Proceedings of the National Academy of Sciences, v. 105. no. 6, February 12, 2008 at 1789.
[40] Ramanathan and Carmichael 2008 *supra* note 19.
[41] Rignot 2008 *supra* note 31.
[42] Rignot 2008 *supra* note 31.
[43] Boggild, C. E.; Warren, S. G.; Brandt, R. E.; Brown, K. J, Effects of dust and black carbon on albedo of the Greenland ablation zone, American Geophysical Union, Fall Meeting 2006.
[44] Qian 2009 *supra* note 26.

B. Black Carbon Climate Forcing Indirectly Contributes to Sea Level Rise

As land ice melts, sea levels rise. Recent NASA research indicates that Arctic melt and climate change are happening faster than previously expected.[45] More than two trillion tons of ice has melted from polar ice sheets since 2003, half of that from Greenland alone, and net ice loss continues to increase.[46]

An increase in sea level of even a few centimeters is expected to have major social and economic impacts on coastal regions from flooding and storm surges; half the world's population lives within 60 kilometers of coasts.[47]

New evidence indicates that a sea level rise of 0.8 meters is likely to occur by 2100, or up to two meters if melting increases rapidly.[48] (Climate scientists had previously assumed that the melting of the Greenland ice sheet, for example, which would result in a sea level rise of seve meters, would happen over 1,000 years or more.)[49]

The warming effect of black carbon on high-altitude and high-latitude snow and ice is thus a significant indirect contributor to sea level rise. This increases climatic threats to World Heritage sites with coral reefs and coastal wetlands. As these sites become submerged or deeper below sea level, their outstanding universal values are threatened.

C. Coral Reefs Are Threatened by Sea Level Rise

Worldwide, coral reef systems are under great threat from the impacts of climate change. Black carbon indirectly contributes to these pressures on coral reef systems through sea level rise and reduced salinity from the melting of glaciers, snow pack, and sea ice. Reef-building corals and their zooxanthellae require light and thus will remain healthy only in the upper layers of tropical oceans.[50] Sea level rise will cause reef ecosystems at the depth limit of coral growth to experience light conditions that will no longer sustain coral growth. [51] As a result, coral communities at these depths will go extinct.[52] Slower growing species will die as rates of sea level rise outpace their growth rates.[53] Though new space for growth will become available in the upper regions of coral growth, only fast growing species will be able to keep pace with sea

[45] Maplecroft Global Risks Portfolio, NASA data on land-ice melt has severe implications for coastal communities, Ethical Insight, Issue 104, 04 Dec 2008 - 14 Jan 2009
[46] Id.
[47] Id.
[48] Mascarelli, A. What We've Learned in 2008. Nature Reports—Climate Change, v. 3, Jan 2009; see also Rignot 2008.
[49] Id.
[50]Hoegh-Goldberg, O., Climate change, coral bleaching and the future of the world's coral reefs, Marine Freshwater Research, CSIRO Publishing, 1999.
[51] Id.
[52] Id.
[53] Id.

level change.[54] While fast growing coral species such as members of the genus *Acropora* can grow up to 20 cm per year,[55] slower growing species such as *Porites* grow only about 1 cm per year.[56] These species will grow with reduced structural strength, making them more vulnerable to storms and erosion.[57] Coral growth rates are about 100 times slower than reef accretion.[58] Where reefs are growing rapidly with sea level rise, the corals may be less consolidated and weaker in response to storms and other causes of erosion.[59] Computer model simulations have demonstrated that coral reefs in the Caribbean will be unable to keep up with the predicted rates of sea level rise.[60] Loss of sunlight due to sea level rise increases environmental stresses on corals, which makes them more susceptible to bleaching events.[61]
Even a moderate rise is sea levels will present serious challenges for reef ecosystems, when combined with other stresses such as sea temperature rise. [62]

Salinity changes induced by sea level rise from the freshwater of glaciers and snowpack are also a major threat to coral reef systems. Coral reefs exist in salinities ranging from 25 to 42 percent.[63] The lower end of the salinity tolerance range can kill corals and cause bleaching.[64] The World Heritage Committee has recognized that coral bleaching can be caused by changes in salinity, and that decreased growth and reproductive capacity occurs in corals that survive bleaching events.[65]

D. Coastal Lands Are Threatened by Sea Level Rise

Coastal lands around the world are seriously threatened by climate change impacts, especially sea level rise. Sea level rise is the greatest threat to mangroves because mangrove growth worldwide is not keeping pace with destruction caused by such rise.[66] Mangrove ecosystems grow in the intertidal zones of tropical and sub-tropical regions and are expected to

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[54] Id.
[55] Done, T. J., Coral community adaptability to environmental change at the scales of regions, reefs, and reef zones. American Zoologist 39, 1999.
[56] Barnes, D. J., Growth in colonial scleractinians. *Bulletin of Marine Science* 23(2), 280.98, 1973; *see also* Barnes, D., and Lough, J., The nature of skeletal density banding in scleractinian corals: fine banding and seasonal patterns. Journal Experimental Marine Biology Ecology, 126, 119.34, 1989.
[57] Id.
[58] Hoegh-Goldberg 1999 *supra* note 50.
[59] Id.
[60] Graus, RR. and I.G. Macintyre, Global Warming and the Future of Caribbean Coral Reefs, Carbonates and Evaporites, v. 13, no. 1, Northeast Science Foundation, 1998.
[61] Smith, S.V. and Buddemeier, R.W., Global change and coral reef ecosystems, Annual Review of Ecological Systems, 23, 1992.
[62] Id.
[63] Great Barrier Reef Marine Park Authority, 'Principal water quality influences on Great Barrier Reef ecosystems' < http://www.gbrmpa.gov.au/corp_site/key_issues/water_quality/principal_influences.html>.
[64] Id.
[65] UNESCO 2007 *supra* note 9.
[66] Gilman, E., Ellison, J., Duke, N.C. and Field, C. 'Threats to Mangroves from Climate Change and Adaptation Options: A Review'. *Aquatic Botany*, *89* 1, 2008.

provide early indicators of the impacts of climate change.[67] Impacts upon mangrove forests, wetlands and coastal marshlands threaten to undermine entire ecosystems, with catastrophic consequences for animal and human populations relying upon them. Black carbon indirectly contributes to these pressures on coastal lands through sea level rise from the melting of glaciers and snow pack.

The World Heritage Committee has recognized that coastal ecosystems are sensitive to the physical and chemical changes of climate change, including flooding, loss of wetlands and mangroves, sea water intrusion into freshwater sources, increases in the extent and severity of storm impacts, coastal erosion, and changes in water temperature and oceanic circulation patterns.[68]

E. Reducing Black Carbon Is a Key Strategy to Slow Arctic and Montane Glacial Melt

> *Ramping up mitigation efforts quickly enough to avoid an increase of 2 C to 2.5 C ... would require very rapid success in reducing emissions of [methane] and black soot worldwide, and it would require that global* CO_2 *emissions level off by 2015 or 2020 at not much above their current amount....*[69]

The Arctic is warming about twice as fast as the rest of the earth, and the Greenland ice sheet is melting twice as fast as the global mean.[70] Climate scientists are now calling on policy makers to reduce short-lived climate forcers including black carbon as a way of preventing Arctic and other glacial sites from reaching irreversible tipping points due to global warming.[71] Tipping points include melting of the Greenland ice sheet and sea level rise, changes in ocean currents, and melting of Arctic permafrost and the resulting methane release. Reducing these emissions could be the fastest strategy for protecting arctic and montane glaciers,[72] and could slow global warming by 40 percent.[73] Targeting emissions of short-lived climate forcing agents including black carbon is one of the best ways to constrain the length and delay the onset of the Arctic melt season.[74]

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[67] C. D. Field, 'Impact of expected climate change on mangroves' *Hydrobiologia* 295 (1995)
[68] UNESCO/World Heritage Centre, Case Studies on Climate Change and World Heritage, 2007, at 28-29.
[69] Scientific Expert Group Report on Climate Change and Sustainable Development (2007), *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable.* R. Bierbaum, et. al. eds, United Nations Foundation, Washington DC.
[70] ACIA, Arctic Climate Impact Assessment, Cambridge University Press, 2005, http://www.acia.uaf.edu; *see also* Quinn et al. 2008 *supra* note 23.
[71] See, for example, the testimonies to the U.S. House of Representatives by Dr. Charles Zender, Dr. Tami Bond, Dr. V. Ramanathan and Dr. Mark Jacobson, October 2007, available at: http://oversight.house.gov/story.asp?ID=1550.
[72] Zender 2007 *supra* note 7.
[73] Jacobson 2007 *supra* note 23.
[74] Norwegian Institute for Air Research, *Short Lived Pollutants and Arctic Climate*, Workshop, November 2008, http://niflheim.niluy.no/spac.

Though reducing the global atmospheric burden of long-lived forcers such as carbon dioxide is key to any meaningful effort to mitigate climate forcing, given the multi-year atmospheric lifetime of CO_2, reductions may not be achieved in time to delay rapid melting in the Arctic and at high altitudes.[75] Because black carbon remains in the atmosphere for only days or weeks, reducing emissions can be an effective rapid response to slow warming in the near term, buying critical time to realize reductions in long-lived greenhouse gases like carbon dioxide.[76] This will allow the extraordinary cultures, biodiversity and ecosystems of the region time to adapt to warming that will continue to occur as a result of past and future emissions of longer-lived greenhouse gases.

F. Black Carbon Reaches the Arctic from Many Geographic Regions

Black carbon may be taken out of the atmosphere by precipitation close to the source of pollution, or it may be transported long distances from the source of emissions. Most black carbon that deposits in the Arctic originates as fuel combustion by-products emitted in North America and Europe (primarily north of 40 degrees latitude) and from East Asia.[77] Approximately 70 to 90 percent of the black carbon in the Arctic comes from fuel combustion.[78] Sources include diesel vehicles and generators, oil and gas flaring and marine transport.[79] In Greenland, most black carbon deposited on ice and snow comes primarily from diesel sources in North America and possibly Europe.[80] Outside Greenland, Arctic regions have black carbon deposition patterns that more closely follow European and former Soviet Union emissions patterns.[81] East Asia contributes most of the black carbon to the upper atmosphere over the Arctic (excluding Greenland).[82] (South Asian black carbon rarely reaches the Arctic, as it remains at lower latitudes.)[83]

G. Sectoral Contributions to Black Carbon in the Arctic

Each region of the world has a unique mix of natural and anthropogenic aerosol sources that create complex climate effects. Black carbon makes up a varying percentage of fine

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[75] Id.
[76] Ramanathan 2007 *supra* note 10;*See also*: McConnell, J.R., Edwards, R., Kok, G.L., Flanner, M.G., Zender, C.S., Saltzman, E.S., Banta, J.R., Pasteris, D.R., Carter, M.M. and J.D.W. Kahl. 2007. 20th-Century Industrial Black Carbon Emissions Altered Arctic Climate Forcing. Science, 317: 1381-1384.
[77] Ramanathan, 2007 *supra* note 10; *see also* Zender 2007 *supra* note 7.
[78] Zender 2007 *supra* note 7.
[79] Quinn et. al. 2008 *supra* note 23.
[80] McConnell et al *supra* note 76; *see also* Shindell, D., J.-F. Lamarque, N. Unger, D. Koch, G. Faluveg, S.Bauer, and H. Teich,, Climate forcing and air quality change due to regional emissions reductions by economic sector, Atmos. Chem. Phys. Discuss., 8, 11609–11642 (2008).
[81] Shindell et al. 2008 *supra* note 80.
[82] Shindell et al 2008 *supra* note 80; *see also* Koch, D., T.C. Bond, D. Streets, N. Unger, and G.R. van der Werf, Global impacts of aerosols from particular source regions and sectors, Journal of Geophysical Research, 112,2007.
[83] Koch et al. 2007 *supra* note 82 at 14.

particulate emissions depending on the source, fuel type and combustion efficiency. Because all sources of black carbon also emit other particulates, such as organic carbon, that have a cooling effect on climate, mitigation approaches should target sources that have the highest ratios of black to organic carbon.[84] Since emissions from fossil fuels contain significantly more black carbon than organic carbon compared to emissions from biomass burning, reducing black carbon from fossil fuels is a powerful mitigation strategy.[85] Emissions from on- and off-road diesel engines and some industrial combustion are particularly important sources in North America and Europe, while East Asia's largest sources of black carbon are coal used in residential heating, cooking, energy and industrial sectors, as well as diesel.[86]

Within industrialized countries, diesel is the largest contributor to black carbon from fossil fuels.[87] In Europe, the greatest sources of black carbon are road transport and non-road transport (ships, planes and trains). In the former USSR, the greatest contributors of black carbon are industry, non-road transport and residential coal burners.[88]

As sea ice melt opens up the Arctic to new and expanded industrial development and new shipping routes, increased local black carbon emissions will further accelerate Arctic melt.[89]

H. Sources of Black Carbon in Montane Regions

Industry and residential coal burners emit the most black carbon affecting the Himalaya.[90] In the Andes and other montane regions in developing countries sources of black carbon are less well researched but likely include diesel road transport (busses, trucks and vehicles), non-road transport (airplanes), and non-road diesel engines (tractors, generators, and construction and other industrial equipment). Other significant sources may include smelters, mining operations, residential heating, oil and gas flaring, and coal burning power plants. In the Rockies and Alps significant local sources of black carbon are likely to be diesel road and non-road transport.[91]

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[84] *See*: McConnell et al. 2007 *supra* note 76; *see also* Bond, T.C., and H. Sun (2005), Can reducing black carbon emissions counteract global warming?, Environmental Science and Technology, 39, no. 16, at 5923; see also Hansen, J. (2005), Efficacy of climate forcings, Journal of Geophysical Research 110, 776.
[85] Bond, T. C., D. G. Streets, K. F. Yarber, S. M. Nelson, J.-H. Woo,and Z. Klimont (2004), A technology-based global inventory of black and organic carbon emissions from combustion, J. Geophys. Res.,109(D14203), doi:10.1029/2003JD003,697
[86] Shindell et al. 2008 *supra* note 80.
[87] Bond and Sun 2005 *supra* note 84.
[88] Bond *et al*., 2004 *supra* note 850.
[89] Lack, D., B. Lerner, C. Granier, T. Baynard, E. Lovejoy, P. Massoli, A.R. Ravishankara and E. Williams, Light absorbing carbon emissions from commercial shipping, Geophysical Research Letters, 35, L13815(2008).
[90] Bond et al. 2004 *supra* note 2.

[91] Bond et al. 2004 *supra* note 85.

I. Mitigating Strategies for Black Carbon

Rapid increased application of existing technologies could dramatically reduce black carbon emissions from these major sources, buying valuable time for the implementation of strategies to reduce greenhouse gases. [92] Black carbon can be sharply reduced in the near-term by improving the efficiency of fuel combustion, as well as by installing particle traps on diesel engines and the smokestacks of power plants and industrial facilities. Replacing raw coal with charcoal briquettes in cookstoves and residential heating stoves in developing countries would also greatly reduce black carbon emissions.[93] Mitigation options for ships and aircraft in the Arctic include fuel switching, improved engine technologies, and speed reduction for ocean going vessels.[94] The use of diesel generators upwind of glaciers should also be phased out.[95]

III. World Heritage Sites Threatened by Black Carbon's Climate Forcing

A. Threatened Glacier and Montane World Heritage Sites

1. *Ilulissat Icefjord – Greenland / Denmark*

The Ilulissat Icefjord is located on the west coast of Greenland, 250 kilometers north of the Arctic Circle. The Icefjord is the sea mouth of Sermeq Kujalleq, formerly known as Jakobshavn Glacier, one of the few glaciers through which the Greenland ice cap reaches the sea.[96] Sermeq Kujalleq is one of the fastest and most active glaciers in the world, and is an outstanding example of the last ice age of the Quaternary Period. It annually calves more than any other glacier outside Antarctica. It has been studied for over 250 years and has been integral in developing our understanding of climate change and icecap glaciology.[97] The Ilulissat Icefjord was inscribed as a World Heritage site in 2004 under World Heritage selection criteria (vii) and (viii).[98]

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[92] *See* UNEP 2008 *supra* note 22; Quinn et al. 2008 *supra* note 23; Ramanathan and Feng 2009 *supra* note 12; Lack et al 2008 *supra* note 89; Reddy and Boucher 2007 *supra* note 13; Hansen and Nazarenko 2004 *supra* note 17;
[93] Boucher, O. and M.S. Reddy (2008), Climate trade-off between black carbon and carbon dioxide emissions, Energy Policy, 36, 193-200.
[94] Lack et al 2008 *supra* note 89.
[95] *See* Quinn et al 2008 *supra* note 23; *see also* Warren, S. and A.D. Clarke, Soot in the Atmosphere and Snow Surface of Antarctica, Journal of Geophysical Research, 95, no. D2, 1990.
[96] http://whc.unesco.org/pg.cfm?cid=31&id_site=1149;
[97] Id.
[98] Id; World Heritage Selection Criteria referenced in this petition are:

(i) to represent a masterpiece of human creative genius;

(vi) to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria);

(vii) to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;

The Ilulissat Icefjord is the pre-eminent glacier in the northern hemisphere in terms of the annual volume of ice it produces (equivalent to 10 percent of the Greenland ice sheet production) and the high velocity at which the ice discharges into the sea (seven kilometers per year). Its other distinctive characteristic is the intensive erosion caused by the ice stream which is greater than any other and provides the world's most outstanding example of large-scale valley and fjord forming processes. The dramatic setting of the Icefjord with its continuous active movement is a natural phenomenon not found to this extent elsewhere.[99]

This site will be significantly affected by climate change because the rate of atmospheric temperature increase is most pronounced in the Arctic. According to the recent Arctic Climate Impact Assessment, the local warming above Greenland could be one to three times higher than the average rate of global warming.[100] A four degree Celsius increase in atmospheric temperature would eliminate nearly all glaciers on earth;[101] about 3 degrees of warming might initiate the long-term deterioration of the Greenland Ice Sheet as temperatures above freezing spread across the plateau in summer.[102]

The World Heritage Committee has recognized that climate change will further affect the outstanding universal values of the site, as well as the rate of the glacial flow and the position of the Sermeq Kujalleq ice front. [103] Glacial melt will also impact regional climate and surrounding areas of heath, fell-field, snow-patch, herb-slope, willow-scrub, fen, riverbank, seashore and aquatic ecosystems. The upwelling caused by calving icebergs brings up nutrient-rich water which supports prolific invertebrate life and attracts great numbers of fish, sea birds, seals and whales. The area boasts over twenty species of fish and numerous seabird breeding colonies.

(viii) to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;

(ix) to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals;

(x) to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

99 Id.
100 ACIA, Impact of a Warming Arctic: Arctic Climate Impact Assessment, Cambridge University Press, 2004, http://www.acia.uaf.edu;
101 Oerlemanns, J., et al., Modelling the Response of Glaciers to Climate Warming, Climate Dynamics, 14, pp.267-274, 1998.
102 Weller, G., et al., Summary of Synthesis of the Arctic Climate Impact Assessment, 2005, Cambridge University Press. This assessment was prepared over five years by an international team of over 300 scientists, other experts, and knowledgeable members of the indigenous communities.
103 UNESCO 2007 *supra* note 9.

Land birds include several species of geese, snow buntings, rock ptarmigan and Peregrine falcon. Land mammals include arctic hare and arctic fox.[104]

Black carbon deposition in Greenland, and on the Sermeq Kujalleq icefield in particular is correctable by human action. Mitigation strategies include reducing diesel use near the site and in Greenland, and fuel switching in ships operating in the Icefjord as well as in Greenland's waters. Speeding up the reduction of diesel emissions in the US and Canada will also have a profound effect on the amount of black carbon deposited to ice and snow in Greenland.[105]

Ilulissat Icefjord meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

2. *Sagarmatha National Park - Nepal*

Sagarmatha is the Nepalese name for Mount Everest, also called Chomolungma, Goddess Mother of the World[106] by Tibetans. The 114,800 hectare[107] site was inscribed on the World Heritage List in 1979[108] under criterion (vii).[109] Sagarmatha is an area famous for dramatic mountains, glaciers and deep valleys, and is dominated by Mount Everest, the highest peak in the world (8,848 m).[110] The area lies in the Solu-Khumbu District of the north-eastern region of Nepal. More than two dozen major glaciers exist in the Park [111] feeding dozens of major glacial lakes and numerous rivers and streams that converge and exit the Park through the Dudh Kosi river. This river feeds into the Ganges River, which sustains 40 percent of India's irrigated croplands and is home to over 400 million people.[112]

Many of the features that constitute the outstanding universal values of the Sagarmatha National Park are the result of, or linked to, past climate variability. Up until the end of the Little Ice Age, snow accumulated in the Sagarmatha National Park, inciting the formation of glaciers. The action of these glaciers contributed to the geological features of the Park, since, as ancient rivers of compressed snow, they crept through and shaped the landscape.[113]

Since the mid 1970's, the average air temperature has risen by 1 degree C in the Himalayas

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[104] World Heritage Nomination IUCN Technical Evaluation; http://whc.unesco.org/archive/advisory_body_evaluation/1149.pdf

[105] McDonnell et al. 2007 *supra* note 76.

[106] http://earthobservatory.nasa.gov/IOTD/view.php?id=1155;

[107] http://www.unep-wcmc.org/sites/wh/pdf/Sagarmatha.pdf;

[108] http://whc.unesco.org/archive/advisory_body_evaluation/120.pdf;

[109] For an explanation of World Heritage Criteria, see note 98.

[110] http://whc.unesco.org/en/list/120/;

[111] Figure 7.5 "Glaciers and glacial lakes of the Dudh Koshi Basin." Database on Glaciers and Glacial Lakes of Nepal and Bhutan, prepared by International Centre for Integrated Mountain Development (ICIMOD) and the United Nations Environment Programme's Regional Resource Centre for Asia and the Pacific (UNEP/RRC-AP). www.rrcap.unep.org/glofnepal/Nepal/Report-pic/html/7_5.html

[112] http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=550&ArticleID=5978&l=en;

[113] UNESCO 2007 *supra* note 9.

– almost twice as fast as the global average warming of 0.6 degrees C. This warming has reduced the glacier area by 4.9 percent since the 1950s, from 403.9 to 384.6 km2.[114] Twelve new glacial footlakes have formed in the region in recent decades; one, Imja Dzo which started to form in the 1970s, is now 1,200 ha in area and 45 meters deep.[115] There is high potential for glacial lake outburst floods (GLOFs) triggered by falling ice blocks and sudden breaching of the unstable dams behind which they have formed. Such floods have already occurred in the region since 1977.[116] Studies of glacial sites within the area that have retreated show the majority of glaciers are losing mass. [117]

A measurement for black carbon in a 40 meter-deep ice core[118] retrieved from the East Rongbuk Glacier in 2002 in the northeast saddle of Mt Everest provided the first historical record of black carbon deposition during the past 50 years in the high Himalayas.[119] Ice core samples and modeling[120] have shown that South Asia's black carbon emissions have had significant impacts on the black carbon deposition in the Everest region.[121] Field observations and satellite aerosol sensors reveal that concentrations of atmospheric brown clouds, of which black carbon is the primary warming aerosol, peak close to major source regions. Regional hotspots have been identified, including the Indo-Gangetic plains in South Asia and Eastern China,[122] making these areas the most likely source of black causing atmospheric warming contributing to the retreat of Himalayan glaciers. Analyses of temperature trends on the Tibetan side of the Himalayas reveals warming in excess of 1 degree C since the 1950s. This large warming trend at high altitudes is likely to be the causal factor for the retreat of Sagarmatha's glacial melting.[123]

Further research is needed to identify sources and mitigation option for black carbon in the atmosphere and on the ice and snow of Sagarmatha. Mitigation strategies for regional black carbon reduction include efforts such as Project Surya,[124] which focuses on technology transfer for more efficient cooking and heating stoves in the region.

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[114] Salerno, F, et al, Glacier surface-area changes in Sagarmatha national park, Nepal, in the second half of the 20th century, by comparison of historical maps, Journal of Glaciology Volume 54, No 187, 2008.
[115] http://www.unep-wcmc.org/sites/wh/pdf/Sagarmatha.pdf;
[116] Id.
[117] Salerno et al. 2008 *supra* note at 114.
[118] Core Sample REF: ERIC2002C.
[119] Ming, J., H. Cachier, C. Xiao, D. Qin, S. Kang, S. Hou, and J. Xu, Black carbon record based on a shallow Himalayan ice core and its climatic implications, Atmospheric Chemistry and Physics, 8, 1343–1352, 2008.
[120] Modelling undertaken using the Hybrid Single Particle Lagrangian Integrated Trajectory Model ("HYSPLIT") - a system for computing simple air parcel trajectories to complex dispersion and deposition simulations.
[121] Ming et al. 2008 *supra* note 119
[122] Ramanathan and Carmichael 2008 *supra* note 19.
[123] Ramanathan and Carmichael 2008 *supra* note 19.
[124] Ramanathan and Feng 2009 *supra* note 12..

Sagarmatha National Park meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

3. *Three Parallel Rivers of Yunnan Protected Areas – China*

This site consists of eight geographical clusters of protected areas within the boundaries of the Three Parallel Rivers National Park in the mountainous north-west of Yunnan Province. The 1.7 million hectare site features sections of the upper reaches of three of the great rivers of Asia: the Yangtze (Jinsha), Mekong and Salween run roughly parallel through steep gorges which are in places 3,000 meters deep and are bordered by glaciated peaks including those of the Meili Snow Mountains over 6,000 meters high. The site is one of the richest temperate regions of the world in terms of biodiversity.[125]

The site encompasses most of the natural habitats in the Hengduan Mountains, one of the world's most important remaining areas for the conservation of the earth's biodiversity including the rare and endangered Giant Panda. The outstanding topographic and climatic diversity of the site, coupled with its location at the juncture of the East Asia, Southeast Asia, and Tibetan Plateau biogeographical realms and its function as a north-south corridor for the movement of plants and animals marks it as a unique landscape that retains a high degree of natural character despite thousands of years of human habitation.[126]

Three Parallel Rivers of Yunnan Protected Areas was inscribed on the list of World Heritage in 2003 under criteria (vii), (viii), (ix), and (x).[127] For more information on this site, see the World Heritage Committee’s webpage profile at http://whc.unesco.org/en/list/1083.

Studies into glacial retreat have been undertaken at sites located in the Hengduan Mountain Range of the eastern Himalayas in the Kham Tibetan region of northwestern Yunnan Province.[128] It is estimated that the Hengduan Mountains have approximately 1680 glaciers covering 1619 km^2.[129] Additionally, the glaciers of this region occur at some of the lowest recorded elevations in China. Due to these unique characteristics, these glaciers are extremely sensitive to climatic changes.[130] The Mingyong Glacier has retreated approximately 190 meters since its first recorded position in 1998, and the rate of retreat appears to be increasing. These results are consistent with the observations of other glaciers in northwestern Yunnan, including the Baishui Glacier Number 1, which has retreated 250 meters from 1982 to 2002.[131] Glaciers in

[125] http://whc.unesco.org/en/list/1083.
[126] Id.
[127] For an explanation of World Heritage Criteria, see note 98.
[128] Baker, B. B. and R. K. Moseley, Advancing Treeline and Retreating Glaciers: Implications for Conservation in Yunnan, P.R. China, The Nature Conservancy Global Climate Change Initiative, Department of Animal Science, Colorado State University, Fort Collins, Arctic, Antarctic and Alpine Research, Vol. 39, No. 2, 2007, pp. 200–209.
[129] Huang 1991.
[130] Baker and Moseley 2007 *supra* note 128.
[131] Id.

the Yangtze River source region have a recession rate of approximately 1.7 percent. There are more retreating glaciers than advancing ones, and the number of retreating glaciers has increased since 1994.[132]

The observed retreat of the Hindu Kush-Himalayan-Tibetan glaciers caused by atmospheric brown clouds and black carbon is one of the most serious environmental problems facing Asia. These glaciers and snow packs provide the head-waters for three major Asian rivers, the Mekong, Yangtze and Salaween, providing water for close to 3 billion people.[133] Melting of these glaciers poses severe threats to the outstanding universal values of the Three Parallel Rivers of Yunnan Protected Areas as well as the water security of downstream regions.

Mitigation options to reduce black carbon deposition on these glaciers includes switching fuels used in residential heating and cooking using raw coal, wood and dung to using charcoal briquettes in efficient stoves. Diesel particulate traps, scrubbers on industrial smokestacks, retirement of super-emitting vehicles, and other technology adaptations could have a dramatic effect on black carbon and atmospheric brown clouds in the region.[134]

Three Parallel Rivers of Yunnan Protected Areas meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

4. *Swiss Alps Jungfrau-Aletsch – Switzerland*

The Jungfrau-Aletsch-Bietschhorn site is the most glaciated part of the European Alps, containing two of longest glaciers in western Eurasia. A diverse flora and fauna is represented in a range of habitats, and plant colonization in the wake of retreating glaciers provides an outstanding example of plant succession. The site was listed in 2001, and its boundaries extended in 2007, based on criteria (vii) (viii) and (ix).[135]

The Committee has recognized that the global phenomenon of climate change is particularly well-illustrated in the region, as reflected in the varying rates of retreat of the different glaciers, providing new substrates for plant colonization. The Committee has also recognized that the Aletsch glacier is of significant scientific interest in the context of glacial history and processes related to climate change.[136]

Because 75 percent of the Swiss Alps glaciers are likely to have disappeared by 2050 the World Heritage Committee has recognized that climate change is a key management

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[132] Id.
[133] UNEP 2008 *supra* note 22.
[134] See Section II.I above.
[135] http://whc.unesco.org/en/list/1037/; For an explanation of World Heritage Criteria, see note 98.
[136] Id.

issue in the region.[137] Swiss glaciers are melting at an accelerating rate and many may vanish this century.[138]

The Aletsch Glacier is the largest glacier in the Alps, and in Europe. If melted, it would provide a liter of water a day for every person on earth for six years.[139] Retreating by up to 50 meters per year, the Aletsch glacier has been dramatically affected by ablation in recent years.[140] About 80 percent of the surface of the glacier may be gone by 2100.[141] Glacial melting in the Alps will affect important European rivers including the Rhine, the Rhone and the Danube, posing a threat to Europe's freshwater supply. In the years to come, discharge from glacier melting will increase, causing more frequent floods. Over the long term, some regions of Europe may face significant decrease in freshwater supply.[142]

Mitigation options for black carbon deposition on these glaciers include improved diesel emissions standards for both road and non-road transport in the region (locomotives and aircraft), as well as reducing emissions from industrial smokestacks and agriculture.

Swiss Alps Jungfrau-Aletsch-Bietschhorn meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

5. *Kilimanjaro National Park – United Republic of Tanzania*

At 5,895 m, Kilimanjaro is the highest point in Africa. One of the largest volcanoes in the world,[143] its three snowy peaks loom over the savannah below. The mountain is encircled by mountain forest, habitat for many endangered mammals.[144] The property is listed as World Heritage under criteria (iii) and (iv).[145]

The peak of Kibo still retains permanent ice and snow although the area covered has been diminishing and one glacier extends down to 4500m. A plateau near the Kibo peak retains glaciers over 11,000 years old. The peak of Mawenzi also has patches of semi-permanent ice, and substantial accumulations of seasonal snow and ice. Evidence of past glaciation is present

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[137] UNESCO, Case Studies on Climate Change and World Heritage, 2007.
[138] Results of two studies undertaken by the Swiss Federal Institute of Technology; see http://news.bbc.co.uk/2/hi/science/nature/7770472.stm.
[139] http://www.stopglobalwarming.org/sgw_read.asp?id=1028187172007.
[140] http://www.pronatura.ch/aletsch/dokumente/aletschglacier_en.pdf.
[141] Marquand, R., Swiss glacier retreats at a rapid clip, 17 July 2007; http://www.stopglobalwarming.org/sgw_read.asp?id=1028187172007,;
[142] UNESCO 2007 *supra* note 9.
[143] http://whc.unesco.org/archive/advisory_body_evaluation/403.pdf.
[144] http://whc.unesco.org/en/list/403.
[145] http://whc.unesco.org/archive/advisory_body_evaluation/403.pdf; For an explanation of World Heritage Criteria, see note 98.

on all three peaks, with morainic debris found as low as 3,600m.[146] In the thermally homogeneous atmosphere of the tropics, the interaction between glaciers and climate represents a particularly sensitive process.

The World Heritage Committee has recognized that as a result of the combined effect of global climate change and local land use changes, the glaciers of Kilimanjaro have lost 80 percent of their area during the twentieth century.[147] At the Kibo cone of Kilimanjaro, the total ice cover diminished from12,058m^2 in 1912 to 3,305m^2 by 1989. If the current trends are not slowed, losing more than half a meter in thickness each year will likely lead to the complete disappearance of the Kilimanjaro ice fields in less than 15 years, while the peak glaciers will continue to retreat. [148]

Sources of atmospheric black carbon in East Africa are primarily from the residential burning of biofuels.[149] Further studies are needed to identify geographic source regions and mitigation options, such as use of improved efficiency cookstoves and mechanisms to reduce open burning of crop residues, grasslands, and forests.

Kilimanjaro National Park meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

6. *Waterton Glacier International Peace Park – Canada/United States*

Waterton Glacier International Peace Park, an area of 457,614ha straddling the border of southwest Alberta in Canada and Montana in the United States, became the world's first International Peace Park in 1932.[150] The area provides habitat for a rich array of species and is valued for its prairie, forest, and alpine and glacial features. The site was listed in 1995 under criteria (vii) and (ix).[151] Waterton Glacier is subject to strong influences by Pacific weather systems, and contains a spectacular mountain landscape and a tri-oceanic watershed divide. [152]

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[146] http://whc.unesco.org/archive/advisory_body_evaluation/403.pdf.
[147] UNESCO, Case Studies on Climate Change and World Heritage, 2007;
[148] Kaser, G. et al., Modern Glacier Retreat on Kilimanjaro as Evidence Of Climate Change: Observations and Facts, International Journal of Climatology 24: 329 – 339 (2004); see also http://researchnews.osu.edu/archive/scndkili.htm.;
[149] Bond et al 2004 *supra* note 85 at 30.
[150] UNESCO World Heritage Centre, 'Waterton Glacier International Peace Park'; http://whc.unesco.org/en/list/354.
[151] For more on World Heritage selection criteria, see note 98.
[152] International Union for the Conservation of Nature, 'IUCN Summary: Glacier and Waterton Lakes National Parks (USA – Canada), November 1995.

Climate change poses a serious threat to Waterton Glacier International Peace Park.[153] There are currently less than twenty-seven glaciers remaining in Glacier National Park,[154] down from 150 glaciers in 1850.[155] Since that time, the area covered by glaciers in Glacier National Park has fallen by 73 percent.[156] Scientists predict all glaciers in the park will disappear by 2030.[157] Increased snow and glacial melt in the area is causing fluctuations in water temperatures. Several species of the temperature-sensitive caddis fly family *Hydropsycidae* have shifted out of the McDonald Basin where they were previously well established.[158]

Management authorities for the site have recognized that climate change is already damaging aspects of the area that justified its World Heritage listing:

> Climate change has and will continue to have important impacts to the International Peace Park [sic] natural resources. Scientific data collected in Glacier indicates that park glaciers have shrunk dramatically over the past century; that the park's tree line is creeping higher in elevation; that the alpine tundra zone is shrinking, and that subalpine meadows are filling in with tree species. The ecological significance of losing the park's glaciers is likely affecting stream baseflow in late summer and increasing water temperatures thus influencing the distribution and behavior of aquatic organisms and food webs.[159]

Meltwater from snowpack and glaciers in Waterton-Glacier flows into three separate oceans. About 70 percent of annual precipitation in the area falls as snow at high elevations.[160] One of the major risks to the integrity of this hydrological process is a "trend toward later maximum snowpack accumulation . . . [and] earlier snowmelt, potentially creating more intense spring run-off and flooding."[161]

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[153] Thorson, E., A Stasch, C Scott, K Gibel and K McCoy, 'Petition to the World Heritage Committee requesting the inclusion of Waterton-Glacier International Peace Park on the List of World Heritage in Danger as a Result of Climate Change and for Protective Measures and Actions' ,2006.

[154] U.S. National Park Service, Glacier National Park, Resources, Geology, Glaciers, available at http://www.nps.gov/glac/resources/geology.htm.

[155] U.S. National Park Service, Glacier National Park, Environmental Management Plan, August 2004, available at http://www2.nature.nps.gov/air/features/docs/GlacFinalEMS200408.pdf.

[156] Id.

[157] Hall, M. and Daniel B. Fagre, *Modeled Climate-Induced Glacier Change in Glacier National Park 1850-2100,* 53 Biosience 131 (2003) p. 137.

[158] Fagre, D. et al, *Watershed Responses to Climate Change at Glacier National Park,* 33 Journal of the American Water Resources Association 755, 764, Aug. 1997.

[159] United States Department of the Interior and Parks Canada, Periodic Report on the Application of the World Heritage Convention, Report on the State of Conservation of Waterton-Glacier International Peace Park, s 5b (considered by the World Heritage Committee July 2005) available at http://www.nps.gov/oia/topics/Waterton-Glacier.pdf.

[160] Selkowitz, D. et al., *Interannual Variations in Snowpack in the Crown of the Continent Ecosystem,* 16 Hydrological Processes 3,651, 3,653 (2002). The waters in the park flow to the Pacific Ocean, the Arctic Ocean, and the Atlantic Ocean.

[161] Fagre, D. *Glacier National Park Biosphere Reserve: Its Suitability for the Mountain Research Initiative,* 5–6 (prepared for Global Change Research in Mountain Biosphere Reserves Launching workshop held in Entibuch

There has been limited research on the role of black carbon and atmospheric brown clouds upon these processes of change, though particulate matter levels are monitored.[162] Visibility is consistently poorer at Glacier Park than at Waterton.[163] Soot on snow in the Western U.S. warms snow and the air above it by up to 1.2 degrees Fahrenheit, causing snow melt and thinner snowpack that reflects less light and further warms the area.[164]

Waterton-Glacier meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

7. *Huascarán National Park – Peru*

Huascarán National Park is located in the world's highest tropical mountain range, the Cordillera Blanca. It was inscribed on the World Heritage List in 1985 under criteria (vii) and (viii).[165] Mount Huascarán rises to 6,768 meters above sea-level, and is surrounded by deep ravines, glacial lakes and habitat of endangered flora and fauna, including the spectacled bear and the Andean condor.[166]

The World Heritage Committee has recognized that about 22 percent of the mass volume of glaciers of the Cordillera Blanca has disappeared since the late 1960s.[167] Two million people live in the vicinity of the Park are threatened by potentially catastrophic landslides, glacial lake outburst flooding and water shortages that will result from the loss of glaciers. Extreme droughts in the region are worsened by El Niño events. In 50 years, scientists predict there will be no glaciers in the Cordillera, and a severe water shortage in the region that threatens not only the outstanding universal values of this World Heritage site, but also the terrestrial biodiversity of the area, traditional agriculture of the region, and food security for millions of people. The fungus 'Rancha' that once affected potatoes only at lower altitudes is now found in the Park at higher altitudes. Sites with outstanding cultural heritage, such as the archaeological site of Willcahuain, are threatened by landslides of soil and debris that becomes unstable once glacial ice is gone.[168]

Biosphere Reserve Nov. 10-13, 2003), available at www.unesco.org/mab/mountains/Fagre_org.doc_Supplemental_Result.

[162] CEPA/FPAC Working Group on Air Quality Objectives and Guidelines (1998) 'National Ambient Air Quality Objectives for Particulate Matter: Executive Summary', p. 9.

[163] Hoff, R, L Guise-Bagley, M Moran, K McDonald, Z Nejedly, I Campbell, S Pryor, Y Golestani and W Malm *Recent visibility measurements in Canada,* Proceedings of Annual Meeting of the Air and Waste Management Associations, 1997.

[164] Qian, Y. et al, Effects of soot-induced snow albedo change on snowpack and hydrological cycle in western U.S. based on WRF chemistry and regional climate simulations, Journal of Geophysical Research – Atmospheres, 2009.

[165] For more information on World Heritage selection criteria, see note 98.

[166] http://whc.unesco.org/en/list/333.

[167] A.C. Byers, (forthcoming), Contemporary Cattle and Human Impacts on Alpine Ecosystems in the Huascarán National Park, Cordillera Blanca, Peru.

[168] World Heritage Centre, Case studies on Climate Change and World Heritage, 2007.

In Peru, the glacier-covered area has been reduced by 25 percent in the last three decades.[169] Ice cores from the summit of Quelccaya showed that melting at the summit in 1991 had occurred for the first time in 1,500 years.[170] Air pollution from black carbon and other aerosols in Peruvian urban and industrial centers will reduce precipitation downstream from pollution sources, as well as warming the troposphere and causing melting of dirty ice and snow.[171]

Mitigation options in the region include partial or full diesel particulate filters on vehicles, retirement of superemitting vehicles, fuel switching in residential heating and cooking using wood to using charcoal briquettes in efficient stoves, scrubbers on industrial smokestacks, and other technology adaptations could have a dramatic effect on black carbon and atmospheric brown clouds in the region.[172]

Huascaran National Park meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

8. *Pyrénées - Mont Perdu – Spain/France*

The Pyrénées – Mt. Perdu World Heritage site spans 30,639 hectares of the mountainous border of France and Spain, centred around the 3,352 meter high massif of Mount Perdu. The site contains two of Europe's largest and deepest canyons on the Spanish side and three major cirque walls on the more abrupt northern slopes on the French side.[173] The site has an outstanding scenic landscape with pastoral traditional agriculture as well as meadows, lakes, caves and forests on mountain slopes, and is of high interest to science and conservation. There is a humid maritime climate on the northern slopes and a drier Mediterranean climate on the southern aspects.[174] Six vegetation zones occur from Mediterranean evergreen forests at the lower elevations to rock and scree communities at the summits.[175] Over 3,500 vascular plant species have been recorded, 200 of them endemic.[176] The site was inscribed in 1997 under criteria (iii), (iv), (v), (vii), and (viii).[177]

The World Heritage Committee has recognized that the warming climate has already changed the landscape of high mountains and could lead to the disappearance of glaciers in the

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[169] Barnett, T.P., J.C. Adam & D.P. Lettenmaier, Potential impacts of a warming climate on water availability in snow dominated regions, Nature, Vol. 438, November 2005.
[170] Id.
[171] Id.
[172] See Section II.I above.
[173] http://whc.unesco.org/en/list/773.
[174] IUCN, World Heritage Nomination – IUCN Technical Evaluation, Pyrénées - Mont Perdu, 1997.
[175] Id.
[176] Id.
[177] For information on World Heritage selection criteria, see note 98.

near future.[178] More research is needed on the levels and sources of black carbon in the atmosphere over the Pyrénées - Mont Perdu, and black carbon depositions on ice and snow in the region. Mitigation options to slow glacial melt and protect the outstanding universal values of the site include diesel particulate traps, scrubbers on industrial smokestacks, fuel switching for locomotives and airplanes, and other engine efficiency technologies.

Pyrénées - Mont Perdu meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

B. Low-lying World Heritage Sites Threatened: Coral Reefs

1. *Great Barrier Reef – Australia*

The Great Barrier Reef, located off the east coast of Queensland, is a huge area of nearly 39 million hectares.[179] At 2,100 kilometers in length, it is the world's most extensive stretch of coral reef and is considered to contain the world's richest diversity in fauna, with about 400 species of coral, 1500 species of fish, 4000 species of mollusc, and 242 species of birds.[180] In addition, there is tremendous diversity in sponges, anemones, marine worms and crustaceans.[181] The site was inscribed in 1981 under criteria (vii),(viii),(ix), and (x).[182] The site comprises 2500 individual reefs of all sizes, providing some of the most spectacular marine scenery on earth.[183] The area provides habitat for a number of endangered species, including the dugong, the green turtle, and the loggerhead turtle.[184] For more information about the Great Barrier Reef, see http://whc.unesco.org/en/list/154.

The Great Barrier Reef Marine Park Authority has recognized that climate change and coral bleaching are likely to pose the greatest long-term risks to the Great Barrier Reef.[185] In 1998, 65 percent of inshore reefs in the area suffered 10 percent coral bleaching; 25 percent of inshore reefs suffered above 70 percent coral bleaching.[186] About 14 percent of offshore reefs

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[178] UNESCO World Heritage Committee, Report of the joint UNESCO/ICOMOS mission, Pyrénées - Mont Perdu (France/Espagne) (773bis) (ICOMOS/UICN/UNESCO), 2007.
[179] UNESCO World Heritage Centre, 'Great Barrier Reef', accessed <http://whc.unesco.org/en/list/154> at 20 January 2009
[180] International Union for Conservation of Nature, 'IUCN Technical Review: Great Barrier Reef' July 1981, p.1.
[181] Id.
[182] For information on World Heritage Criteria, see note 98.
[183] Id.
[184] UNESCO World Heritage Centre, 'Great Barrier Reef', accessed <http://whc.unesco.org/en/list/154> at 20 January 2009
[185] Chin, A., "Corals" in, State of the Great Barrier Reef On-Line, Townsville: Great Barrier Reef Marine Park Authority, June 2004.
[186] Hoegh-Guldberg, O. 'Climate change, coral bleaching and the future of the world's coral reefs' *Marine and Freshwater Research*, CSIRO Publishing 50, 1999, at 861.

suffered above 70 percent bleaching.[187] Most corals in the area recovered, but in some places over 50 percent of the corals died. At one reef crest site, mortality was recorded at 80 to 90 percent.[188] Corals as old as 700 years died, suggesting that 1998 was one of the most severe events in the past several hundred years.[189] In 2002, another mass bleaching event occurred which was more severe and extensive than the 1998 event. Sixty-nine percent of inshore reefs showed high levels of bleaching, while 51 percent of mid-shelf and offshore reefs showed moderate to high levels of bleaching.[190]

Deteriorations in reef systems will have serious consequences for birds and marine mammals in the area. In 1998, nesting by the black noddy tern on Heron and One Tree Islands in the south of the Great Barrier Reef failed and adult mortality was high.[191] This may have been caused by reduced populations of fish prey as a result of the reduced productivity of coral reefs earlier in the year.[192]

Bleaching events in the Great Barrier Reef are predicted to increase to 10 per decade by 2030.[193] Coral cover is expected to decrease to less than 5 percent on most reefs by the middle of the century, even under the most favourable assumptions.[194] In this context, even moderate rise in sea level due to melting of high latitude and altitude glaciers will exacerbate coral death in this ecosystem.

Great Barrier Reef meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

2. *Belize Barrier Reef – Belize*

The Belize Barrier Reef is an area of 96,300ha[195] covering seven separate protected areas.[196] The area consists of the largest barrier reef in the northern hemisphere, offshore atolls,

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[187] Id.
[188] Id., p. 857.
[189] ISRS, Statement on Global Coral Bleaching in 1997, 1998, International Society for Reef Studies, December 1998 in Ove Hoegh-Guldberg, 1999 ‘Climate change, coral bleaching and the future of the world’s coral reefs’ *Marine and Freshwater Research,* CSIRO Publishing 50, p. 857
[190] Chin 2004 *supra* note 185.
[191] Hoegh-Guldberg 1999 *supra* note 186.
[192] Id.
[193] Id., p. 861.
[194] Hoegh-Guldberg, O., The Implications of Climate Change for Australia’s Great Barrier Reef, QTIC and WWF, 2004, at 2.
[195] UNESCO World Heritage Centre, ‘Belize Barrier Reef System’ < http://whc.unesco.org/en/list/764> accessed 19 January 2009.
[196] UNEP, World Conservation Centre < http://www.wcmc.org.uk/marine/data/>

several hundred sand cays, mangrove forests, coastal lagoons and estuaries.[197] The site was inscribed in 1996 under criteria (vii) (ix) and (x). [198]

The site provides an outstanding example representing significant ongoing ecological and biological processes including a "classic example of reefs through fringing, barrier and atoll reef types."[199] In 1842, Charles Darwin described the area as "the most remarkable reef in the West Indies." It is one of the most pristine reef ecosystems in the Western Hemisphere, and provides important habitat for a number of internationally threatened marine species and several endemic and migratory bird species.[200]

The major threat to the Belize Barrier Reef is coral bleaching.[201] Already, the frequency and intensity of disturbances to reefs of the region have increased.[202] In 1998, bleaching caused mass mortality of hard corals on Belize lagoon reefs, which was the first time that a coral population in the Caribbean had collapsed completely from bleaching.[203] The bleaching event caused long term damage; in some areas coral losses were as high as 75 percent.[204] A study of the reef after the event found that "if corals are unable to recover substantially, vertical accretion will be slowed or possibly arrested over the next several decades, at a time when sea-level rise is expected to accelerate due to global warming." [205]

Belize Barrier Reef meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

3. *Tubbataha Reef Marine Park – Philippines*

Tubbataha Reef Marine Park is an area of 33,200ha made up of a pristine coral reef and spectacular 100 meter perpendicular wall, extensive lagoons and two coral islands. The site provides a unique atoll reef with very high density of marine species, including birds and marine turtles.[206] The diverse coral species in the area represent 46 genera.[207] The site was inscribed in

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[197] UNESCO World Heritage Centre, 'Belize Barrier Reef System' < http://whc.unesco.org/en/list/764> accessed 19 January 2009

[198] Id.; For information on World Heritage Criteria, see note 98.

[199] Id.

[200] Id.

[201] *See e.g*. Kramer, Philip A. and Patricia Richards Kramer. *Ecoregional Conservation Planning for the Mesoamerican Caribbean Reef (MACR),* 14 (May 2002).

[202] Id.

[203] Aronson, Richard B. & William F. Precht, Ian G. Macintyre, and Thaddeus J.T. Murdoch. "Coral bleach-out in Belize". *Nature* Vol.405. May 2000.

[204] Almada-Villela, Patricia & Melanie McField, Phillip Kramer, Patricia Richards Kramer, and Ernesto Arias-Gonzalez "Chapter 16- Status of Coral Reefs of MesoAmerica: Mexico, Belize, Guatemala, Honduras, Nicaragua, and El Salvador." *Status of Coral Reefs of the World: 2002*, 314.

[205] Aronson et al. 2000 *supra* note 204.

[206] UNESCO World Heritage Centre, 'Tubbataha Reef Marine Park' accessed <http://whc.unesco.org/en/list/653> at 20 January 2009

[207] International Union for Conservation of Nature, IUCN Summary, January 1992, p. 1.

1993 under World Heritage criteria (vii) (ix) and (x).[208] The site includes an almost pristine reef crest and reef edge, extensive reef flat, deep lagoon with coral beds and giant clams, shallow lagoon with seagrass beds important for threatened turtle species, and emergent islands used by both birds and turtles.[209]

The coral reef ecosystem has demonstrated considerable resilience and ability to recover from bleaching.[210] The area showed a decrease in mean live coral cover of 24.9 percent from 1997 to 1999. This has been attributed to the coral bleaching of 1998,[211] when more than 21 percent of the reef's benthic communities were affected.[212] From 1999 to 2000 there was an increase in live coral cover of 3.3 percent that may indicate recovery in the area.[213] Sea level rise may affect this site by reducing the corals' ability to recover from bleaching events, as well increasing coral death at greater depths and weakening the structure of new reefs. Typhoons in the region would then cause increasing structural damage to these ecosystems.

Tubbataha Reef Marine Park meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

4. *Aldabra Atoll – Seychelles*

The Aldabra Atoll is an area of 35,000ha with four large coral islands enclosing a shallow lagoon.[214] Aldabra is the least disturbed island in the Indian Ocean and provides an area of outstanding scientific interest.[215] Due to the lack of human influence in the area, the area retains 152,000 giant tortoises.[216] The tortoises were once found throughout the Indian Ocean but are now found only on the Aldabra Atoll. On all other Indian Ocean islands, human exploitation drove the tortoises to extinction.[217] There are two endemic birds and 11 other birds

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[208] UNESCO World Heritage Centre, 'Tubbataha Reef Marine Park' accessed <http://whc.unesco.org/en/list/653> at 20 January 2009; For information on World Heritage Criteria, see note 98.
[209] IUCN1992 *supra* note 207, p. 2.
[210] United Nations Environment Programme, World Conservation Monitoring Centre, 'Tubbataha Reefs Natural Park: Philippines' accessed < http://www.unep-wcmc.org/sites/wh/pdf/TUBBATAHA.pdf> at 20 January 2009, p. 5.
[211] Ledesma, MC and Mejia, M. Coral reef monitoring in Tubbataha Reef National Marine Park, Sulu Sea, Philippines, Proceedings of the Ninth International Coral Reef Symposium, Bali, 23-27 October 2000, Volume 2. pp. 879-881. 2002.
[212] UNEP 2009 *supra* note 210.
[213] Ledesma et al. 2002 *supra* note 211.
[214] UNESCO World Heritage Centre, 'Aldabra Atoll' <http://whc.unesco.org/en/list/185> accessed 16 January 2009
[215] International Union for Conservation of Nature, 'IUCN Technical Review Aldabra Atoll', 15 April 1982, p.1.
[216] UNESCO 2009 *supra* note 214.
[217] IUCN 1982 *supra* note 215.

of distinct subspecies.[218] Of these, the Aldabran White-throated Rail is the last western Indian Ocean flightless bird.[219]

The area was inscribed in 1982 under criteria (vii), (ix), and (x).[220] The most significant threat to the site is climate change.[221] There is evidence that sea level rise is already having an impact on ecological processes on and around Aldabra in the form of beach erosion.[222] Beach erosion appears to be occurring at multiple areas and threatens turtle nesting beaches.[223] Further rises in sea level will contribute to greater erosion of coral islets and cause a reduction of vegetation available for tortoise food.[224]

The impacts of sea level rise threaten to combine with other climate change impacts, such as extended dry seasons and severe coral bleaching, to undermine habitat of the tortoises and other animals.[225] For example, in 2007 it was reported that the extinction of the Aldabra banded snail *Rhachistia aldabrae* may be a result of direct impacts on climate.[226] In 1997-‘98, a major coral bleaching event destroyed significant amounts of coral in the Aldabra’s reefs. Although regeneration has occurred, further damage was reported in 2002.[227]

Aldabra Atoll meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

C. World Heritage Sites in Coastal Lands Threatened by Sea Level Rise

5. *Doñana National Park – Spain*

Doñana National Park is an area of 54 thousand hectares at the estuary where the Guadalquivir River empties into the Atlantic.[228] The area contains great diversity in its biotopes, especially lagoons, marshlands, fixed and mobile dunes, scrub woodland and Mediterranean scrubland (*maquis*).[229] The site provides a home to five threatened bird species and is one of the

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[218] Id.
[219] Id.
[220] UNESCO 2009 *supra* note 214; For information on World Heritage Criteria, see note 98.
[221] Seychelles Islands Foundation, ‘Initial Assessment: Report of Initial Management Effectiveness Evaluation: Aldrabra Atoll’, September 2002, p. 2.
[222] Id., p. 11.
[223] Id., p 101.
[224] Id., p. 11.
[225] Id., p. 101.
[226] Justin Gerlach, ‘Short-term climate change and the extinction of the snail *Rhachistia aldabrae* Gastropoda: Pulmonata) *Biology Letters* (2007) 3:5, 581-584.
[227] Seychelles Islands Foundation, ‘Initial Assessment: Report of Initial Management Effectiveness Evaluation: Aldrabra Atoll’, September 2002, p. 101
[228] UNESCO World Heritage Centre, ‘Doñana National Park’, < http://whc.unesco.org/en/list/685> accessed 19 January 2009.
[229] Id.

largest heron nesting sites in the Mediterranean.[230] The area was inscribed in 1994 and extended in 2005 under natural criteria (vii), (ix) and (x).[231] The area contains that last marshes of the Guadalquivir unaltered by agriculture or development. These marshes constitute an example of geological processes during the Pleistocene.[232] The area is also noted for its 38 kilometers long pristine beach.[233] Finally, it contains breeding populations of several globally-threatened animals (marbled teal, white-headed duck, Adalber's eagle, Spanish lynx) and plant species.[234] Each year the area receives more than 500,000 water fowl each year.[235]

Sea level at the site has risen by about 20 centimeters between 1899 and 1999.[236] Future sea-level rise at Doñana National Park will threaten the remaining wetland areas through saltwater inundation.[237] If the marshes of Doñana are unable to adapt to sea level rise they will eventually be drowned.[238] The impacts of sea level rise threaten the survival of Doñana National Park as a migratory bird habitat.[239]

Doñana National Park meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

6. *Komodo National Park – Indonesia*

Komodo National Park is an area over 200 thousand hectares, comprised of volcanic islands inhabited by around 5,700 'Komodo dragons.'[240] These giant lizards are found nowhere else in the world.[241] The site also features some of the world's most diverse coral reefs.[242] The site was inscribed in 1991 under natural criteria (vii) and (x).[243] For more information on Komodo National Park, see http://whc.unesco.org/archive/advisory_body_evaluation/609.pdf.

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[230] International Union for Conservation of Nature, 'World Heritage Nomination – IUCN Technical Evaluation: Doñana National Park (Spain)' May 2005, p. 105
[231] UNESCO World Heritage Centre, 'Doñana National Park', < http://whc.unesco.org/en/list/685> accessed 19 January 2009; For information on World Heritage Criteria, see note 98.
[232] International Union for Conservation of Nature, 'World Heritage Nomination – IUCN Summary: Doñana National Park (Spain)' April 1994, p. 42
[233] Id.
[234] Id.
[235] International Union for Conservation of Nature, 'World Heritage Nomination – IUCN Technical Evaluation: Doñana National Park (Spain)' May 2005, p. 105
[236] Hulme and Sheard, 1999 'Climate Change Scenarios for the Iberian Peninsual' Climatic Research Unit, Norwich at <www.cru.uea.ac.uk/~mikeh/research/wwf.iberia.pdf> accessed 19 January 2009.
[237] Id.
[238] D. Eisma, *Climate Change: Impact on Coastal Habitation* CRC Press 1995, p. 192
[239] Hulme and Sheard, 1999 'Climate Change Scenarios for the Iberian Peninsual' Climatic Research Unit, Norwich at <www.cru.uea.ac.uk/~mikeh/research/wwf.iberia.pdf> accessed 19 January 2009.
[240] UNESCO World Heritage Centre, 'Komodo National Park' accessed <http://whc.unesco.org/en/list/609> at 20 January 2009
[241] Id.
[242] Id.
[243] Id. For an explanation of World Heritage Criteria, see note 98.

The World Heritage Committee has recognized that climate change poses a particular threat to the area.[244] Sea level rise will erode nesting beaches of sea turtles and threatens the conservation of mangrove forests, which will need to recede at pace with the progressing shoreline.[245] The mangrove forests of the area are likely to suffer erosion, inundation and loss from sea level rise.[246] This is particularly the case for fringing mangroves backed by high relief terrain that will have limited space to expand inland.[247] Mangroves in low-lying areas may be rapidly inundated as they have limited sedimentation to build upon and shift location.[248] Mass bleaching of coral reefs in the northern park of the area occurred in 1998-99.[249] It is unclear what impact sea level rise or more broadly climate change will have upon the Komodo dragon.[250]

Komodo National Park meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

7. *Kakadu National Park - Australia*

Kakadu National Park is nearly 2 million hectares in size and has been inhabited continuously for more than 40,000 years.[251] The park provides a rich array of landscapes and ecosystems, including tidal flats, floodplains, lowlands and plateaux.[252] There are about 473 km^2 of coastal, intertidal and estuarine areas and two islands in the park, and over 64 mammal, 275 bird, 128 reptile, 25 frog and 59 freshwater and estuarine fish species in the area.[253] About 2.5 million waterbirds use the floodplains in the park.[254]

The site was inscribed in 1981 (with extensions to the site in 1987 and 1992) under critieria (i) (vi) (vii) (ix) (x).[255] It provides an outstanding example of both ancient and recent geological changes to the Australian continent as it incorporates all the major landforms of the Northern Territory of Australia and provides an example of various periods of biological evolution of Australian fauna.[256] It is also an example of the ecological effects of sea-level change in northern Australia through its coastal rivers and flood plains. The landscape remains intact due to little interference by European settlement in contrast to the rest of Australia. Upon

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[244] UNESCO 2007 *supra* note 9.
[245] Id.
[246] Id.
[247] Id.
[248] Id.
[249] Id., p. 39
[250] Id., p. 38
[251] UNESCO World Heritage Centre, 'Kakadu National Park' accessed <http://whc.unesco.org/en/list/147/> at 21 January 2009
[252] Id.
[253] International Union for Conservation of Nature, 'IUCN Summary: Kakadu National Park', March 1992, p. 131.
[254] Id.
[255] UNESCO World Heritage Centre, 'Kakadu National Park' accessed <http://whc.unesco.org/en/list/147/> . For information on World Heritage criteria, see note 98.
[256] International Union for Conservation of Nature, 'IUCN Summary: Kakadu National Park', March 1992, p. 132.

inscription the IUCN noted, “the archaeological remains and rock art represent an outstanding example of man’s interaction with the natural environment. They bear remarkable witness to past environments in northern Australia and to the interaction of human beings with these environments.”[257] The area contains a vast expanse of internationally important wetlands and the escarpment.[258] It provides significant habitats for threatened species of plants and animals, and is both unique and representative of northern Australian biomes. The Park incorporates an almost complete river system as well as land forms and habitats that are found nowhere else.[259]

Sea level rise poses a great threat to the park. All wetlands in the region below four meters in elevation are vulnerable.[260] There is evidence that the coastal wetlands of Kakadu are undergoing very substantial alteration as a result of shoreline retreat.[261] The floodplain wetlands are generally only three to four meters above Australian Height Datum – making them only 0.2-1.2 meters above mean high water level.[262] Sea level rise, shoreline erosion and saltwater intrusion are expected to destroy salt and freshwater wetland resources.[263] This would result in reduction in or loss of some components of the mangrove fringe on the coast line, extensive loss of *Melaleuca* trees, and the replacement of freshwater wetlands with saline mudflats.[264]

There is evidence that the tidal creek extension and dieback of *Melaleuca* through saltwater intrusion is partially a consequence of long-term rise of high tide levels.[265] The lower floodplain palaeocreek and palaeochannel environments are at risk.[266] If the sea level rises to a level that re-establishes tidal connections between the downstream floodplain and the central high of the Magela Creek system it is likely that the upstream sections of the plain will be more poorly drained.[267] It is unclear what impact these changes will have upon the conservation of aquatic birds in the area.[268] Widespread changes to the natural environment of Kakadu may also impact the cultural values of the area.[269]

Kakadu National Park meets the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

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[257] Id., p. 132-133.
[258] Id., p. 133.
[259] Id.
[260] Department of Environment Report (1997) ‘Vulnerability assessment of predicted climate change and sea level rise in the Alligator Rivers Region, Northern Territory Australia’ accessed <http://www.environment.gov.au/ssd/publications/ssr/123.html> at 21 January 2009
[261] Id., p. 70.
[262] Id., p. 65.
[263] Id., p. 72.
[264] Id.
[265] Id., p. 32.
[266] Id.
[267] Id.
[268] Id., p. 74.
[269] Id., p. 71.

8. *Sundarbans National Park – India, and The Sundarbans – Bangladesh*

The Sundarbans mangrove forest ecosystem spans straddles a border of India and Bangladesh and comprises two World Heritage sites. At 10,000km^2 it is the largest mangrove forest in the world. The next largest is only about one-tenth the size.[270] The area lies within the delta of the Ganges, Brahmaputra and Meghna rivers on the Bay of Bengal.[271] It is intersected by a complex network of tidal waterways, mudflats, and small islands of mangrove forests.[272] The area provides habitat for 260 bird species, the Bengal tiger, the estuarine crocodile and the Indian python. The Bangladesh Sundarbans Reserve Forest provides subsistence livelihood for about 3.5 million inhabitants.[273]

Sundarbans National Park, an area of 133,010ha, was inscribed in 1987; the Bangladesh area of 139,500ha was inscribed in 1997. Both were inscribed under criteria (ix) and (x).[274] The site provides one of the world's major habitat areas for Bengal tigers and a range of other fauna.[275] The area also plays a unique role in buffering cyclones and provides an exceptional display of the effects of monsoonal rains, flooding, delta formation, tidal influence and plant colonization.[276]

The World Heritage Committee has recognized that climate change, especially sea level rise, presents a very serious threat to the Sundarbans mangrove forests.[277] Sea level rise, combined with increased evapotranspiration and lower freshwater flow in winter, will result in increased salinity in the area. If sea levels rise by 45cm, 75 percent of the Sundarbans mangrove forests would be destroyed.[278] A 65 centimeter rise could inundate all of the Sundarbans. Even a

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[270] Shardul Agrawala, Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith and Maarten van Aalst, 'Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans' Environment Directorate Development Co-Operation Directorate, Working Party on Global and Structural Policies; Working Party on Development Co-Operation and Environment accessed <
http://www.sdnpbd.org/sdi/issues/climate_change/21055658.pdf> at 21 January 2009, p. 41
[271] Id., p. 17.
[272] International Union for Conservation of Nature, 'IUCN Technical Evaluation: Sundarban Wildlife Sanctuaries (Bangladesh)', p. 27.
[273] Shardul Agrawala, Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith and Maarten van Aalst, 'Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans' Environment Directorate Development Co-Operation Directorate, Working Party on Global and Structural Policies; Working Party on Development Co-Operation and Environment accessed <
http://www.sdnpbd.org/sdi/issues/climate_change/21055658.pdf> at 21 January 2009, p. 42.
[274] UNESCO World Heritage Centre, 'Sundarbans National Park' accessed <http://whc.unesco.org/en/list/452> at 20 January 2009; For more information on World Heritage Criteria, see note 98.
[275] Id.
[276] International Union for Conservation of Nature, 'IUCN Summary: Sandarbans National Park India', p. 49; *and* International Union for Conservation of Nature, IUCN Technical Evaluation: Sundarban Wildlife Sanctuaries (Bangladesh), p. 29
[277] World Heritage Centre (2007) 'Case Studies on Climate Change and World Heritage', p. 36.
[278] IPCC, 2001, WG2, Section 19.3.3.5.

25 centimeter rise would result in a loss of 40 percent of the mangroves.[279] Such destruction would greatly undermine the role of the mangroves as buffers against tropical cyclones.[280] The Bay of Bengal currently experiences about 10 percent of the world's tropical cyclones, with 17 percent making landfall in Bangladesh.[281] Without the protection of the mangroves, the exposure of the region will substantially increase, with devastating consequences for the 2.5 million people living in the area.[282]

The Sundarbans meet the criterion for the List of World Heritage in Danger: (b) Potential Threat (v) Threatening effects of climatic, geological or other environmental factors.

IV. Actions that the World Heritage Committee Should Take to Protect World Heritage Sites from Black Carbon

A. Actions of the World Heritage Committee to Date on Climate Change

The Intergovernmental Committee for the Protection of the Cultural and Natural Heritage of Outstanding Universal Value ("the World Heritage Committee") has been actively considering the impacts of climate change on world heritage sites since 2004 when it received the first petitions to have World Heritage sites placed on the list of World Heritage in Danger as a result of the effects of climate change. Since 2004, the Committee has received petitions to list Sagarmatha National Park (2004), Huascaran National Park (2004), the Great Barrier Reef (2004), the Belize Barrier Reef Reserve System (2004), Glacier National Park (2006) and the Greater Blue Mountains World Heritage Area (2007) as "in danger" due to the threats posed by climate change. Despite the overwhelming scientific evidence of the various threats that climate change poses to these sites, as summarized in section II above, the Committee has not yet added any of these sites to the List of World Heritage in Danger.

However, the petitions highlighted for the Committee the threats that climate change poses to World Heritage, and at its 29th session in Durban in 2005 the Committee launched an initiative to assess the impacts of climate change on World Heritage and define appropriate management responses in conjunction with the Petitioners.[283] A meeting of experts was held in March 2006 to prepare a report and a strategy to assist State Parties in addressing this threat. The report, titled "Predicting and Managing the Effects of Climate Change on World Heritage,"

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[279] Shardul Agrawala, Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith and Maarten van Aalst, 'Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans' Environment Directorate Development Co-Operation Directorate, Working Party on Global and Structural Policies; Working Party on Development Co-Operation and Environment accessed < http://www.sdnpbd.org/sdi/issues/climate_change/21055658.pdf> at 21 January 2009, p. 19.
[280] UNESCO 2007 *supra* note 9.
[281] L.J. Hansen, J.L. Biringer, J.R. Hoffmann, (eds.), 2003, Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems, WWF, 246pp., <http://assets.panda.org/downloads/buyingtime_unfe.pdf> at 21 January 2009
[282] IPCC, 2001, WG2, Section 11.2.4.5
[283] Decision 29 COM 7B.a

was endorsed by the Committee at its 30th session in Vilnius in July 2006.[284] In it, the Committee took note of the petitions received, and recognized "that the impacts of Climate Change are affecting many and are likely to affect many more World Heritage properties, both natural and cultural in the years to come."[285] The report also encouraged "all States Parties to seriously consider the potential impacts of Climate Change within their management planning, in particular with monitoring, and risk preparedness strategies, and to take early action in response to these potential impacts."[286]

In 2007, the General Assembly of State Parties adopted a Policy Document on the Impacts of Climate Change on World Heritage Properties, which presented possible strategies for dealing with World Heritage Sites threatened by climate change.[287] These included: i) adding them to the In-Danger List, regardless of whether the State Party is responsible for the climate change concerned, or ii) deleting threatened sites from the World Heritage List entirely.[288] The Policy Document does not suggest which of these strategies to choose, or discuss their ramifications. The Policy Document was released by the World Heritage Centre in 2008.

In 2008 at its 32nd session, the Committee adopted amendments to its operational guidelines setting criteria for assessing properties that are most threatened by climate change for inclusion on the List of World Heritage In Danger.[289]

B. The United Nations Framework Convention on Climate Change (UNFCCC)

The World Heritage Committee has indicated that the "UNFCCC is the UN instrument through which [climate change] mitigation strategies at the global and States Parties level [are] being addressed."[290] However, the UNFCCC (including its subsidiary agreement the Kyoto Protocol) does not currently address non-greenhouse gas pollutants such as black carbon that significantly contribute to climate change.

The ultimate objective of the Framework Convention is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[291] The Convention requires industrialized countries to

[284] World Heritage Centre, Climate Change and World Heritage Report on predicting and managing the impacts of climate change on World Heritage and Strategy to assist States Parties to implement appropriate management responses, May 2007; [full cite]
[285] World Heritage Centre, Predicting and Managing the Effects of Climate Change on World Heritage, 2006.
[286] Id.
[287] World Heritage Centre, Policy Document on the Impacts of Climate Change on World Heritage Properties, 2008.
[288] Id.
[289] WHC-08/32.COM/7A
[290] World Heritage Centre, A Strategy to Assist States Parties to Implement Appropriate Management Responses (2006) at part B(9), 2006.
[291] United Nations Framework Convention on Climate Change, Art. 2 (1992).

develop and maintain up-to-date inventories of greenhouse gas emissions[292] and to formulate national programs to "mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases"[293] The Convention defines greenhouse gases as "those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation."[294]

The Kyoto Protocol to the UNFCCC sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas emissions. The Protocol specifies that the greenhouse gases included in the emissions targets are "the six main greenhouse gases, namely: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6)."[295] These emissions reductions amount to an average of five per cent against 1990 levels over the five-year period 2008-2012, known as the "first commitment period."[296]

The State Parties to the UNFCCC are currently negotiating a new international agreement setting emissions targets and establishing mechanisms for accomplishing those targets that will come into effect upon expiration of the Kyoto commitments in 2012. A roadmap for the negotiation process was agreed upon at the 2007 United Nations Climate Change Conference in Bali, Indonesia. The Bali Action Plan establishes a two-year process to finalizing a binding agreement, culminating in the 2009 Climate Change Conference of Parties (COP15) to be held in Copenhagen, Denmark in December 2009. There is no indication that the State Parties to the UNFCCC will move to expand the scope of the Framework Convention and its protocols beyond the six identified greenhouse gases.

C. Authority of the World Heritage Committee to Take Action on Climate Change

The 1972 Convention Concerning the Protection of the World Cultural and Natural Heritage ("the Convention") recognizes that the cultural and natural heritage of mankind is among the priceless and irreplaceable assets, not only of each nation, but of humanity as a whole and considers the loss, through deterioration or disappearance, of any of these most prized assets to be an impoverishment of the heritage of all the peoples of the world.[297] Certain sites or properties within this heritage, because of their exceptional qualities, are considered to be of "outstanding universal value" and as such worthy of special protection against the dangers which increasingly threaten them.[298] The purpose of the Convention is to ensure the proper identification, protection, conservation and transmission to future generations of cultural and

[292] Id. at Art. 4(1)(a).
[293] Id. at Art. 4(1)(b).
[294] Id. at Art. 1(5).
[295] Id. at Annex A.
[296] Kyoto Protocol to the United Nations Framework Convention on Climate Change, Art. 3(1) (1997).
[297] Convention Concerning the Protection of the World Cultural and Natural Heritage, preamble, UNESCO (1972).
[298] Id.

natural heritage of outstanding universal value.[299] The World Heritage Committee is tasked with implementing the Convention and assisting States Parties achieve the goals enshrined therein.[300]

In order to facilitate the implementation of the Convention, the Committee develops Strategic Objectives to define the goals and objectives of the Committee and to ensure that new threats to World Heritage are addressed effectively.[301] The current Strategic Objectives are to:

i. Strengthen the credibility of the World Heritage List;
ii. Ensure the effective conservation of World Heritage Properties;
iii. Promote the development of effective capacity-building in States Parties;
iv. Increase public awareness, involvement and support for World Heritage through communication; and
v. Enhance the role of communities in the implementation of the World Heritage Convention.[302]

As the World Heritage Committee has recognized, the impacts of climate change are affecting many World Heritage properties, both natural and cultural, and are likely to affect many more in the years to come.[303] In the 2006 survey of State Parties, 125 World Heritage sites were noted to be threatened by climate change, with glacial melt and retreat observed at 19 sites, and sea level rise at 18 sites.[304] As demonstrated above, the effects of climate change are amplified and accelerated at latitude and altitude – in the Arctic and in high-altitude glacial and montane environments. Black carbon is a critical climate-forcing agent both in the atmosphere and when deposited on ice and snow. Although the Arctic and high mountain environments seem remote and isolated from more biologically rich and densely populated areas, the melting of glaciers and the Greenland ice sheet is directly linked to sea level rise, which threatens many low-lying parts of the world, including other valued World Heritage sites. Protection of Arctic, glacial and montane sites are essential not only for the preservation of their characteristics of outstanding universal value, but also for the preservation of many other World Heritage sites around the world. Thus the Committee cannot fulfill its mandate of ensuring that new threats to World Heritage are addressed effectively without considering and taking action to address the threats to World Heritage presented by climate change and, in particular, black carbon.

The Committee has a number of tools at its disposal to address the threats presented by climate change and black carbon. These tools include:

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[299] Id.
[300] Id. Art. 8.
[301] Operational Guidelines for the Implementation of the World Heritage Convention, ¶25, UNESCO (2008)
[302] *Id.* at ¶ 26.
[303] World Heritage Committee Decision 30 Com 7.1, WHC-06/30.COM/7.1, (2006).
[304] World Heritage Centre, Predicting and Managing the Effects of Climate Change on World Heritage, 2006.

1. Inscribing World Heritage properties threatened by black carbon on the List of World Heritage in Danger;[305]
2. Using the resources of the World Heritage Fund to assist States Parties to protect their properties from the impacts of black carbon, in particular to assist States Parties to inventory and mitigate black carbon emissions within their territories;[306]
3. Co-operating with international and national governmental and non-governmental organizations working to understand, mitigate, and develop adaptation strategies for black carbon; [307]
4. Increasing awareness among States Parties and the public of the threats that black carbon presents for many World Heritage sites by directing the World Heritage Centre and the Advisory Bodies to coordinate studies and disseminate information on the climate forcing impacts of black carbon on World Heritage;[308]
5. Assessing the impacts of black carbon on the state of conservation of World Heritage properties through the processes of Reactive Monitoring and Periodic Reporting.[309]

These tools are described in more detail below.

1. *The List of World Heritage in Danger*

Pursuant to Article 11.4 of the Convention, the World Heritage Committee is required to establish, keep up-to-date and publish a list of World Heritage sites where "major operations are necessary" for their conservation, and for which assistance has been requested under the Convention, *i.e.*, the "List of World Heritage in Danger."[310]

> The list may include only such property forming part of the cultural and natural heritage as is threatened by serious and specific dangers, such as the *threat of disappearance caused by accelerated deterioration*, large- scale public or private projects or rapid urban or tourist development projects; destruction caused by changes in the use or ownership of the land; major alterations due to unknown causes; abandonment for any reason whatsoever; the outbreak or the threat of an armed conflict; calamities and cataclysms; serious fires, earthquakes, landslides; volcanic eruptions; *changes in water level, floods and tidal waves*.[311]

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[305] *Id.* at Art. 11(4)-(5).
[306] *Id.* at Art. 13(6).
[307] *Id.* at Art. 13(7).
[308] *Id.* at Art. 14.
[309] *World Heritage Convention,* Arts. 11(7), 29.
[310] *Id.* at Art. 11(4).
[311] *Id.* (emphasis added).

The Committee has, pursuant to Article 11.5 of the Convention, defined criteria on the basis of which World Heritage Sites may be included on the List of World Heritage in Danger. These criteria are set out in Section IV(B) of the Operational Guidelines for Implementation of the World Heritage Convention. A World Heritage site can be entered on the List of World Heritage in Danger by the Committee when it meets the criteria for either ascertained or potential danger.[312] In the case of natural properties, the criteria are as follows:

> a) ASCERTAINED DANGER - The property is faced with specific and proven imminent danger, such as:
>
> i. A serious decline in the population of the endangered species or the other species of outstanding universal value which the property was legally established to protect, either by natural factors such as disease or by man-made factors such as poaching.
>
> ii. Severe deterioration of the natural beauty or scientific value of the property, as by human settlement, construction of reservoirs which flood important parts of the property, industrial and agricultural development including use of pesticides and fertilizers, major public works, mining, pollution, logging, firewood collection, etc.
>
> iii. Human encroachment on boundaries or in upstream areas which threaten the integrity of the property.
>
> b) POTENTIAL DANGER - The property is faced with major threats which could have deleterious effects on its inherent characteristics. Such threats are, for example:
>
> i. A modification of the legal protective status of the area;
>
> ii. Planned resettlement or development projects within the property or so situated that the impacts threaten the property;
>
> iii. Outbreak or threat of armed conflict;
>
> iv. The management plan is lacking or inadequate, or not fully implemented;
>
> v. *Threatening effects of climatic, geological or other environmental factors*.[313]

As described earlier in this petition, atmospheric and deposited black carbon is causing both ascertained and potential danger to numerous World Heritage sites including Sagarmatha National Park in Nepal, Ilulissat Icefjord in Denmark, Jungfrau-Aletsch in Switzerland, Huascarán National Park in Peru, Waterton-Glacier International Peace Park in the United States and Canada, Kilimanjaro National Park in Tanzania, Pyrénées-Mt. Perdu in Spain, and the Three Parallel Rivers of Yunnan Protected Areas in China. Black carbon is causing deterioration of the natural beauty and scenic value of these sites by accelerating glacial melt and glacial movement to lower elevations. If the retreat of glaciers and disappearance of ice and snow at these sites

[312] *Operational Guidelines* at ¶178.
[313] *Id.* at 180 (as amended by WHC Decision 32 COM.7A.32) (emphasis added).

continue, the characteristics inherent to the sites' outstanding value as World Heritage may disappear entirely. These sites thus meet the criteria for inscription on the List of World Heritage in Danger.

Black carbon is indirectly endangering various low-lying World Heritage sites described in Section III.B and III.C of this petition because both coral reefs and coastal wetland ecosystems are endangered by sea level rise caused by the melting of glaciers and the Greenland ice sheet. As described in Section X of this petition, glacial melting is caused by both greenhouse gases and emissions of global warming pollutants like black carbon which exert a climate warming effect both in the atmosphere and when deposited on ice and snow. Thus black carbon is indirectly endangering these low-lying sites.

In addition to meeting the criteria of ascertained or potential danger, for a property to be inscribed on the List of World Heritage in Danger, the factors that are threatening the integrity of the property or their deleterious effects must be "amenable to correction by human action."[314] Because black carbon is short-lived, remaining in the atmosphere for just days or weeks compared to long-lived greenhouse gases such as CO_2 which can live in the atmosphere for over 100 years,[315] actions to reduce emissions of black carbon can have an immediate and direct mitigating effect. Reducing emissions of black carbon can be an effective rapid response to slow warming in the near term, protecting arctic and montane glaciers as well as snow pack, permafrost and sea ice, and buying critical time to realize reduction in long-lived greenhouse gases like carbon dioxide. Moreover, although black carbon global warming pollution is an inherently transboundary issue, nevertheless, measures to reduce emissions of black carbon emissions at or near to threatened World Heritage sites can be particularly effective. (See Section II.H, above, for a discussion of black carbon mitigation options.) Thus corrective measures[316] can be taken to mitigate the deleterious effects of black carbon and preserve the characteristics of outstanding universal value of the threatened sites.

The focus of this petition on black carbon distinguishes it from past petitions to list sites due to the general impacts of climate change. Distinct from the situation of long-lived greenhouse gases which can remain in the atmosphere for centuries, reducing black carbon emissions is an effective near-term mitigation measure and has an immediate cooling effect. This petition requests that the Committee take action that is specific, that does not overlap with the work of other international bodies, and that falls squarely within the Committee's mandate under the Convention.

The body of research and evidence documenting the deleterious effects of climate change on World Heritage is substantial. In addition to the six previous petitions asking the Committee

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[314] *Id.* at ¶181.
[315] *Climate Projections Based on Emissions Scenarios for Long-Lived and Short-Lived Radiatively Active Gases and Aerosols,* National Oceanic and Atmospheric Administration Climate Change Science Program, p. 1 (Sept. 2008).
[316] When a site is considered for inclusion on the List of World Heritage in Danger, the Committee must develop a program for corrective measures. *Operational Guidelines* at ¶183.

to inscribe various sites to the List of World Heritage In Danger on the basis of climate-related threats, the Committee and its Advisory Bodies have produced reports on the impacts of climate change on world heritage, a series of cases studies documenting the threats that climate change poses to listed sites including Sagarmatha National Park in Nepal, Huascaran National Park in Peru, and Ilulissat Glacier in Greenland, and a policy document presenting possible strategies for dealing with World Heritage Sites threatened by climate change.

However, these previous petitions and reports have not addressed the global warming impacts of the short-lived pollutant black carbon. As a result, the Committee has been unnecessarily limited in its role to actually protect these sites. Because the effects of climate change are already adversely affecting many World Heritage properties, if no action is taken in the short-term, many World Heritage sites will not survive until these long-term greenhouse gas reduction measures take effect.

2. *The World Heritage Fund*

The World Heritage Fund, created pursuant to Article 15 of the Convention, is administered by the Committee for the purpose of assisting States Parties with the protection of the world cultural and natural heritage located on their territories.[317] The Convention specifies that assistance provided through the Fund may take the following forms:

> (a) Studies concerning the artistic, scientific and technical problems raised by the protection, conservation, presentation and rehabilitation of the cultural and natural heritage;
> (b) Provisions of experts, technicians and skilled labor to ensure that the approved work is correctly carried out;
> (c) Training of staff and specialists at all levels in the field of identification, protection, conservation, presentation and rehabilitation of the cultural and natural heritage;
> (d) Supply of equipment which the State concerned does not possess or is not in a position to acquire;
> (e) Low-interest or interest-free loans which might be repayable on a long-term basis;
> (f) The granting, in exceptional cases and for special reasons, of non-repayable subsidies.[318]

Thus the Convention grants the Committee authority to use the Fund to commission studies on the impacts of black carbon on the protection of World Heritage properties, to assist State Parties and site managers to understand and inventory the sources of black carbon threatening protected properties, and to provide experts to help develop and implement

[317] *World Heritage Convention* Art. 19.
[318] *Id.* at Art. 22.

mitigation and adaptation measures to protect properties from the deleterious global warming effects of black carbon.

The Fund should also be used to facilitate the transfer of equipment and technologies for reducing emissions of black carbon to State Parties in which emissions are directly threatening World Heritage sites. Finally, conservation and management assistance incorporates information dissemination and education in addition to training, research and technical co-operation.[319] Thus the Committee could use the Fund to increase awareness among States Parties and the public of the threats that black carbon presents for many World Heritage sites by directing the World Heritage Center and the Advisory Bodies to coordinate studies and disseminate information on the impacts of black carbon on World Heritage.

3. *Cooperation with International and Non-Governmental Organizations*

Article 13(7) of the Convention directs the Committee to "co-operate with international and national governmental and non-governmental organizations having objectives similar to those of this Convention."[320] Although the Committee has stated that the UNFCCC is the UN instrument through which climate change mitigation strategies are being addressed, it has recognized that there are various ways for the World Heritage community to "participate in climate change mitigation at the level of World Heritage."[321] The Committee has proposed to do this by providing the IPCC and UNFCCC information on the impacts of climate change on World Heritage sites "to assist them in tailoring mitigation strategies,"[322] and by identifying and promoting synergies between adaptation and mitigation at World Heritage sites, acknowledging that "any adaptation measure should seek ways in which to mitigate" climate change.[323]

This petition urges the Committee to coordinate with other UN bodies working on understanding the threats posed by climate change and crafting solutions to mitigate those threats. Because the UNFCCC, the primary international body responsible for these efforts, has not addressed the specific problems that black carbon presents, the World Heritage Committee should take action to understand the impacts of black carbon on World Heritage sites, to disseminate this information to other UN bodies, and to urge these bodies and States Parties to mitigate the impacts of black carbon.

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[319] *Operational Guidelines*, at ¶235(c).
[320] *World Heritage Convention*, Art. 13(7).
[321] World Heritage Centre 2006 *supra* note 304, Section B(9).
[322] *Id.*
[323] *Id.*

4. Studies by the World Heritage Centre and Advisory Bodies on the Impacts of Black Carbon on World Heritage

This petition urges the Committee to increase awareness among States Parties and the public of the threats that black carbon presents for many World Heritage sites by calling upon the World Heritage Centre and Advisory Bodies to coordinate studies and disseminate information on the climate forcing impacts of black carbon on World Heritage, pursuant to World Heritage Convention Article 14.[324]

5. *Reactive Monitoring and Periodic Reporting*

This petition urges the Committee to also assess the impacts of black carbon on the state of conservation of World Heritage properties through the processes of Reactive Monitoring and Periodic Reporting, pursuant to World Heritage Convention Article 11 (7).[325]

V. Conclusion

The World Heritage Committee has the opportunity to advance critical, early action on this issue and take important steps to preserve World Heritage until the effects of the UNFCCC process can be realized. Because the causes of climate change are inherently transboundary, and because the impacts of climate change on such World Heritage sites as the Ilulissat Glacier in Greenland could trigger catastrophic tipping points that would accelerate damage to other diverse sites around the world, protection of World Heritage requires a robust response from the Committee.

The In Danger finding is an important tool for identifying those sites that are most adversely affected, but coordinated international mitigation and adaptation action is also necessary. Accordingly, the Petitioners respectfully request that the World Heritage Committee takes the following actions to address the threats that black carbon pose to World Heritage:

- Request the Advisory Bodies, State Parties and site managers to cooperatively undertake studies to determine the sources of black carbon that are polluting various high latitude and altitude sites and recommend measures that State Parties and site managers could take to reduce emissions from these sources;
- Place the World Heritage sites addressed in this petition on the List of World Heritage in Danger and develop, in consultation with the relevant State Parties, a program for corrective measures that incorporates the results of the studies described above;
- Coordinate with other United Nations bodies working on climate issues to educate these bodies and State Parties on the impacts that climate change and, in

[324] *World Heritage Convention*, Art. 14
[325] *World Heritage Convention*, Arts. 11(7), 29.

particular, black carbon, are having on World Heritage sites and to encourage them to take steps to mitigate the impacts of black carbon;

- Encourage and fund the transfer of available technologies to State Parties and site managers to help mitigate the impacts of black carbon emissions on World Heritage sites.

We hope this Petition will be useful to the Committee as it carries out its responsibility to assist State Parties and the international community to protect World Heritage and ensure the preservation of this heritage for future generations. We would welcome the opportunity to assist the Committee in any way appropriate. Please let us know if we can provide any additional information or be of any further assistance.

Sincerely,

Sarah Burt
Jessica Lawrence
Erika Rosenthal
J. Martin Wagner
Earthjustice
426 17th Street
6th Floor
Oakland CA 94612
United States
Email: jlawrence@earthjustice.org

Keely Boom
Stephen Leonard
Australian Climate Justice Program
Level 13, 235 Jones St.
Ultimo NSW 2007
Australia
Email: keely@cana.net.au