LAST ICE AREA
Potential Transnational World Heritage Property
(CANADA and DENMARK)
The Natural Heritage Protection Fund was established in 2000 in compliance with article 17 of the UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage. The Fund’s priority is the overall support of World Heritage properties, as well as obtaining this status for new natural sites both in Russia and the CIS. http://www.nhpfund.org

This project is financed by …

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Each State Party to this Convention recognizes that the duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage situated on its territory, belongs primarily to that State. It will do all it can to this end, to the utmost of its own resources and, where appropriate, with any international assistance and co-operation, in particular, financial, artistic, scientific and technical, which it may be able to obtain.

UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage
INTRODUCTION

This is one of a series of research resources commissioned by WWF to help inform future management of the Area we call the Last Ice Area (LIA). We call it that because the title refers to the area of summer Arctic Islands, and above Northern Greenland for many more decades. Much life has evolved together with the ice. Creatures from tiny, single-celled animals to seals and walrus, polar bears and whales, depend to some extent on the presence of ice. This means the areas where sea ice remains may become very important to this ice-adapted life in future.

One of my colleagues suggested we should have called the project the Lasting Ice Area. I agree, although it’s a bit late to change the name now, that name better conveys what we want to talk about. While much is changing, and is likely to change around the Arctic, this is the place that is likely to change the least. That is also meaningful for the people who live around the fringes of this area – while people in other parts of the Arctic may be forced to change, and adapt as summer sea ice shrinks, the people around the LIA may not have to change as much.

As a conservation organization, WWF does not oppose all change. Our goal is to help maintain important parts of the natural world, parts that are important just because they exist, and important for people. WWF does not have the power and authority to impose its vision on people. Instead, we try to present evidence through research, and options for action. It is then up to the relevant authorities as to whether they will take action or not; the communities, the Inuit organizations, and the governments of the Last Ice Area will decide its future fate. We hope you will find the information in these reports useful, and that it will help you in making wise decisions about the future of the Last Ice Area.

In this particular document, we are responding to the lead of the Arctic Council’s Conservation of Arctic Flora and Fauna working group, which suggested that a World Heritage site spanning the resilient ice area of Canada and Greenland should be considered by the respective governments, and a discussion document by the Inuit Circumpolar Council that identified a World Heritage Site as an international management option for LIA that would best meet Inuit interests.

Adopted on November 16, 1972, the Convention concerning the Protection of the World Cultural and Natural Heritage is the most efficient and representative among existing nature conservation conventions and programs. The primary purpose of the Convention is to unite the efforts of the international community to identify, protect and provide comprehensive support to cultural monuments and natural objects of Outstanding Universal Value.

Established in 1976, the World Heritage List represents both diverse regions on our planet and a number of specific properties. Many natural properties of worldwide renown are protected under the World Heritage Convention, including the Great Barrier Reef, Galapagos Islands, Lake Baikal, Grand Canyon, Mount Kilimanjaro, Victoria and Iguazu Falls. World Heritage status brings with it numerous advantages, both in terms of nature conservation and in garnering comprehensive support for territories inscribed on the World Heritage List. World Heritage Convention offers its States Parties and their inscribed sites broad legal, informational, economic, and networking opportunities, which have been developing and improving for more than four decades.

Benefits of World Heritage Status for Natural World Heritage Sites:

- Additional guarantees of the full preservation and integrity of unique natural areas.
- Increase in the prestige of natural areas and the institutions governing them.
- Increase in the popularity of territories inscribed on the World Heritage List.
- Greater capacity to attract financial support for World Heritage sites.
- Development of alternative types of natural resource use, including ecological tourism and traditional trades.
- Organization of monitoring and inspection of conservation activities in natural areas.
- Untouched by economic activities and significant in size, the natural World Heritage properties represent a valuable and important strategic natural reserve of humankind.
- The fact of a unique voluntary contribution of any state into a joint "bank of nature of humanity" positively affects the state’s image (Butorin, 2011).

Canada is currently represented on the World Heritage List by eight cultural and nine natural properties. Canada’s natural World Heritage properties are Nahanni National Park, Dinosaur Provincial Park, Kluane / Wrangel-St. Elias / Glacier Bay / Tatshenshini-Alsek (transboundary with the United States of America), Wood Buffalo National Park, Canadian Rocky Mountain Parks, Gros Morne National Park, Waterton Glacier International Peace Park (transboundary with the United States of America), Miqquash National Park, Joggins Fossil Cliffs. The total area of Canadian natural World Heritage properties comprises more than 17.7 million ha. Two of natural properties, Kluane / Wrangel-St. Elias / Glacier Bay / Tatshenshini-Alsek and the Wood Buffalo National Park, are ranked in the top 10 largest properties worldwide. Work is currently being carried out to present more of Canada’s natural and mixed sites for inclusion in the World Heritage List, Attuak / Woodland Caribou / Accord First Nations (Pimachiowin Aki), Gwaii Haanas, Ivauik / Vuntut / Herschel Island (Qikiqtaruk), Mistaken Point, and Quttinirpaaq are all included on Canada’s Tentative List.

Denmark is currently represented on the World Heritage List by three cultural properties, and one natural property, Jutland Icefjord, with the total area of 402 400 ha. Three natural and mixed properties are included on Denmark’s Tentative List: Møler landscapes of the Liim Fiord, Stevns Klint, and the International Wadden Sea (Danish-German-Dutch Wadden Sea). The booklet contains the materials of the transnational nomination Last Ice Area (Canada and Denmark) developed in 2014 by the following organizations: WWF Canada, Natural Heritage Protection Fund, Institute of Geography of the Russian Academy of Sciences, Likhachev Institute for Cultural and Natural Heritage. The booklet is supported by WWF Global Arctic Programme.

The Last Ice Area is unique amongst potential World Heritage sites, as it is nominated not only for what it is, but for what it will be; a locus of resilience in a rapidly changing world. Sea ice projections show this region within decades will be the only place where year-round Arctic sea ice will remain. This will make it increasingly important for ice-obligate and ice-associated marine mammal species. The nominated area and nearby marine environments provide diverse habitats for a multitude of unique life-forms highly adapted in their life history, ecology and physiology to the extreme and seasonal conditions of this environment. This ice-associated life is important not just in its own right, but for what it provides for adjacent Inuit communities, both in terms of sustenance, and in terms of cultural continuity and resilience.

To this future role as an island of stability in a sea of change, should be added its current attractions as a World Heritage site. A unique character of glacial conditions observed at the nominated property – a kind of "open-air glaciology museum" has no analogues in the world. LIA is unique due to the large-scale of contemporary glaciations and level of glacial relief treatment. There is a rich variety of terrestrial and coastal/marine environments with complex and intricate mosaics of life at various successional stages from 500 m below sea level to 5000 m above.
Figure 2. The Arctic Tern, Devon Island.

Nomination LAST ICE AREA

The First Property
Of the Serial Transnational Nomination

LAST ICE AREA
(CANADA and DENMARK)

Proposal for Inscription on
THE UNESCO WORLD CULTURAL
AND NATURAL HERITAGE LIST

Prepared by:
• World Wildlife Fund (WWF) Canada
• Natural Heritage Protection Fund, Russia
• Institute of Geography of the Russian Academy of Sciences

Supported by:
• World Wildlife Fund (WWF) Global Arctic Programme

2014
1. Identification of the property

1a. Country (and State Party if different)
Canada and Denmark.

1b. State, Province or region
Canada: Nunavut territory.
Denmark: Greenland autonomous province.

1c. Name of Property
Last Ice Area.

The nominated property is located on the northern coast of Ellesmere Island (the Canadian Arctic Archipelago) and Greenland; it includes the Quttinirpaaq National Park (Canada), and the northern part of Greenland National Park (Denmark).

1d. Geographical coordinates to the nearest second

<table>
<thead>
<tr>
<th>№</th>
<th>Special Protected Area</th>
<th>Coordinates of centrepoint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Latitude</td>
</tr>
<tr>
<td>CANADA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Quttinirpaaq National Park</td>
<td>82° 7' 56.424&quot; N 71° 38' 53.556&quot; W</td>
</tr>
<tr>
<td>2.</td>
<td>unprotected waters (Robeson Channel)</td>
<td>81°42' 27.108&quot; N 63° 35' 30.372&quot; W</td>
</tr>
<tr>
<td>DENMARK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Greenland National Park</td>
<td>82° 20' 49.128&quot; N 47° 10' 6.384&quot; W</td>
</tr>
<tr>
<td>4.</td>
<td>unprotected waters</td>
<td>81° 39' 41.04&quot; N 62° 42' 20.52&quot; W</td>
</tr>
</tbody>
</table>

1e. Maps and plans showing the boundaries of the nominated property and buffer zone

1. Location of the nominated property within the limits of the Arctic.
2. Map with the exact indication of the boundaries of the nominated property and its buffer zone.

Additional maps and plans:
3. Map of the LIA core area and predicted future sea ice extent.
4. Map of the LIA region with the marine ecoregions and the EBSAs.
5. Map of the LIA region with the terrestrial ecoregions.
6. Seabird colonies in the Canadian and Greenlandic portions of the LIA.
7. Distribution of a) bowhead whales, b) belugas and c) narwhals.
8. Distribution of a) ringed seals (Kelly, 2003), b) bearded seals.
9. Map of location, size and trends of polar bear subpopulations.
10. Protected areas in LIA and its vicinity.
11. Location of current oil and gas rights and potential oil development areas in the Canadian Arctic Archipelago.
**Figure 4. Map with the exact indication of the boundaries of the nominated property.**

### Table: Area of nominated property (ha.) and proposed buffer zone (ha.)

<table>
<thead>
<tr>
<th>No</th>
<th>Special Protected Area</th>
<th>Area, ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Quttinirpaaq National Park</td>
<td>4,584,784</td>
</tr>
<tr>
<td>2.</td>
<td>Unprotected waters (Robeson Channel)</td>
<td>151,760.8</td>
</tr>
<tr>
<td><strong>Total area in Canada:</strong></td>
<td>4,736,544.8</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Greenland National Park</td>
<td>8,152,161</td>
</tr>
<tr>
<td>4.</td>
<td>Unprotected waters</td>
<td>39,816.43</td>
</tr>
<tr>
<td><strong>Total area in Denmark:</strong></td>
<td>8,191,977.43</td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>12,928,522.23</td>
<td></td>
</tr>
</tbody>
</table>

The nominated territory is the first component part of the planning serial transnational property which will be further expanded at the expense of other SPAs located within the boundaries of the Last Ice Area.
2. Description

2a. Description of Property

Working with Arctic Council definitions of the boundary (Figure 5), the Arctic is a vast region that covers more than 40 million square kilometres, and contains about four million people (AHdr (Arctic Human development report), 2004). It consists of the Arctic Ocean and the adjacent terrestrial regions of the United States (Alaska), Canada, Denmark (Greenland), Iceland, Russia, Finland, Norway and Sweden.

The LIA boundaries are fuzzy as they are based on projections of sea ice persistence that are not accurate predictions of the exact location of that ice in the future. Nonetheless, the core of the area of interest includes the Canadian High Arctic Islands (also called the Queen Elizabeth Islands) that are located north of the Parry Channel, and the northern part of Greenland (an imaginary line between the western settlement of Savissivik and the peninsula Krongpits Christian Land) (Figure 6). The communities included in the LIA area are Grise Fiord and Resolute, in Canada, and Qaanaaq, in Greenland.

The LIA includes five marine ecoregions: Beaufort-Amundsen-Viscount Melville-Queen Maud, Lancaster Sound, High Arctic Archipelago, Baffin Bay (Canadian Shelf) and North Greenland (Figure 8). Within these ecoregions, Ecologically and Biologically Significant Areas (EBSAs) were identified (Skjoldal et al., 2012). These areas were selected based on their ecological importance to fish, birds and mammals, as these species are the most widely studied Arctic groups (Skjoldal et al., 2012). These EBSAs are very productive as they each contain a recurrent polynya (area of open water within the sea ice) that is used by sealers as a nesting, breeding and feeding area, and by walruses as haul-out and wintering grounds. Arctic cod, an important link in the Arctic food web, is abundant in these three EBSAs. Lancaster Sound includes three EBSAs: Lancaster Sound, Wellington Channel and Cardigan Strait/Hell Gate. These three EBSAs are very productive as they each contain a recurrent polynya (area of open water within the sea ice) that is used by sealers as a nesting, breeding and feeding area, and by walruses as haul-out and wintering grounds. Arctic cod, an important link in the Arctic food web, is abundant in these three EBSAs. Lancaster Sound is also used as a migration corridor for marine mammals such as bowhead, narwhal, killer whales, and seals, and has the highest known density of polar bears in the world. The High Arctic Archipelago ecoregion comprises six EBSAs. The Archipelago multiyear pack ice is critical as it is the largest remaining island pack ice refugium in the world and it supports unique communities. This area is particularly important for under-ice communities, sealers and polar bears. Norwegian Bay is important for marine mammals and has the most genetically differentiated polar bear population in the world. Ellesmere Island includes three EBSAs: the Ellesmere Island ice shelves (described at section Ice shelves), the Nansen-Eureka-Greely Fiord that supports unique fish communities and aggregations of polar bear and ringed seal, and Princess Maria Bay that is used by several seal species, walrus and narwhal. The Arctic Basin pack ice is the EBSA that contains the thickest and oldest sea ice of the Arctic.

50 representative ecological regions, or ecoregions, have been defined within the circumpolar Arctic (WWF, 2012). The objective of designing ecoregions is to plan for conservation and set priorities (Skjoldal et al., 2012). Thirty-seven marine ecoregions were identified based on recognizable species groups of both plants and animals. Each marine ecoregion is an area of relatively homogeneous species composition that is clearly different from adjacent regions (Spalding et al., 2007). These species groupings are likely the consequences of oceanographic or topographic features such as temperature regimes, ice regimes or upwelling, that lead to biological differences (Spalding et al., 2007).

The LIA includes five marine ecoregions: Beaufort-Amundsen-Viscount Melville-Queen Maud, Lancaster Sound, High Arctic Archipelago, Baffin Bay (Canadian Shelf) and North Greenland (Figure 8). Within these ecoregions, Ecologically and Biologically Significant Areas (EBSAs) were identified (Skjoldal et al., 2012). These areas were selected based on their ecological importance to fish, birds and mammals, as these species are the most widely studied Arctic groups (Skjoldal et al., 2012). These EBSAs are very productive as they each contain a recurrent polynya (area of open water within the sea ice) that is used by sealers as a nesting, breeding and feeding area, and by walruses as haul-out and wintering grounds. Arctic cod, an important link in the Arctic food web, is abundant in these three EBSAs. Lancaster Sound includes three EBSAs: Lancaster Sound, Wellington Channel and Cardigan Strait/Hell Gate. These three EBSAs are very productive as they each contain a recurrent polynya (area of open water within the sea ice) that is used by sealers as a nesting, breeding and feeding area, and by walruses as haul-out and wintering grounds. Arctic cod, an important link in the Arctic food web, is abundant in these three EBSAs. Lancaster Sound is also used as a migration corridor for marine mammals such as bowhead, narwhal, killer whales, and seals, and has the highest known density of polar bears in the world. The High Arctic Archipelago ecoregion comprises six EBSAs. The Archipelago multiyear pack ice is critical as it is the largest remaining island pack ice refugium in the world and it supports unique communities. This area is particularly important for under-ice communities, sealers and polar bears. Norwegian Bay is important for marine mammals and has the most genetically differentiated polar bear population in the world. Ellesmere Island includes three EBSAs: the Ellesmere Island ice shelves (described at section Ice shelves), the Nansen-Eureka-Greely Fiord that supports unique fish communities and aggregations of polar bear and ringed seal, and Princess Maria Bay that is used by several seal species, walrus and narwhal. The Arctic Basin pack ice is the EBSA that contains the thickest and oldest sea ice of the Arctic.
and is a unique habitat for under-ice and planktonic communities, and is a significant summer refuge for polar bears. The Baffin Bay (Canadian Shelf) ecoregion includes three EBSAs: the north Water Polynya (see section Marginal ice zones, flaw leads and polynyas), the Eastern Jones Sound that is characterised by an earlier open water feature that joins the north Water Polynya a few months later, and the northern Baffin Bay that is known as an important seafloor habitat. The north Greenland ecoregion contains Peary Land, an important area for marine mammals and seabirds. Twenty-three Arctic terrestrial ecoregions were identified based on the variation in plant species groups and communities found in clearly recognizable regions (CAVM Team, 2003). Although many plants grow throughout the circumpolar Arctic, variation in some species groups is informative of glacial histories, topography and other factors that might have contributed to regional differences. Soil type, soil moisture and temperature correspond to the different terrestrial ecoregions. The LIA encompasses three terrestrial ecoregions: Ellesmere-Northern Greenland, Central Canada and, to a small extent, Western Greenland (Figure 10). Tundra, permafrost, ice caps and glaciers, the Greenland Ice Sheet and snow characterize the terrestrial portion of the LIA.

The Arctic Islands are underlain by rocks of the Archean and Proterozoic-aged Churchill, Arctic Platform, Franklinian and younger geological provinces. Paleozoic sedimentary rocks mainly occur in the central and western Arctic Islands. The latest known period of widespread mineralization in the area predates these sedimentary rocks, therefore rocks of this age (Paleozoic) or younger may be discounted as favourable sources of metalliciferous deposits. Most of the Arctic Islands fall in this category (Nassichuk 1987). The east coast of Ellesmere and Devon islands and large portions of Baffin and Somerset islands are geologically favourable to mineralization. The geology of these areas is a continuation of the Rae Domain which contains extensive mineralization on the mainland to the south. The region hosts diverse mineral deposits and occurrences including iron ore, base metals such as lead and zinc, gold, platinum group elements (PGE), diamonds and sapphires (AANDC 2012).

At the present time, parts of eastern Ellesmere and Devon Islands are covered by permanent ice caps that make geological exploration activities difficult. There are minor exposures of Rae Domain Archean and Proterozoic rocks without sedimentary cover in these areas. Greenland’s geology is an extension of North America and Northern Europe Archean cratons and Paleozoic-sedimentary basins. Greenland is dominated by crystalline rocks of the Precambrian shield, formed during a succession of Archean and early Proterozoic orogenic events which stabilized as a part of the Laurentian Shield approximately 1,600 million years ago.

Major sedimentary basins formed during late Proterozoic time and throughout the Phanerozoic in north and north-eastern Greenland, and accumulated sedimentary successions 10 to 15 km thick. Paleozoic orogenic belts, the Ellesmerian fold belt of North Greenland, and the East Greenland Caledonides disturbed parts of these successions.
A mountainous region of continuous permafrost, the region consists mainly of land to 700m above mean sea level. The highest highest point is 2600 m. It has substantial coverage of ice caps and glaciers and exposed carbonate bedrocks. The Arctic Ocean consists of a deep central basin (maximum depth of 4400 m) divided by ridges (i.e. a chain of mountains that form a continuous elevated crest) and surrounded by broad and narrow continental shelves (Figure 5; an interactive map can be visualized at www.arcgis.org). It is the smallest of the world’s oceans, but has the highest proportion of open ocean, with shelf regions covering around 50% of the Arctic marine area (Jakobsson et al., 2010), and epishelf lakes. The Arctic also harbours a diversity of streams and river ecosystems, from spring-fed streams to large rivers.

Most Arctic lakes are ultra-oligotrophic and therefore very productive, but are some are heavily enriched by human activities (e.g. Meretta Lake (Schindler et al., 1974)). Several variables would control biological production in Arctic aquatic ecosystems (Vincent et al., 2008). First, the availability of liquid water is essential for aquatic life. For some ecosystems (e.g. meltwater on ice shelves), this limits biological activity to only a few weeks each year. However, liquid water persists all year round under snow and ice cover for most aquatic ecosystems. Streams and rivers are fed by melting snowpack and glaciers, and their flow is the most important during the peak snowmelt in spring. Second, the reduced irradiance, since the sun is up only during the summer season, is an important factor that influences ecosystem productivity. The availability of nutrient for most aquatic ecosystems is strongly controlled by climate. The lake ice cover duration strongly influences the amount of nutrients by sedimentation of particles from above and by more active bacterial decomposition and recycling processes, compared to the water column environment. The benthic photosynthetic communities may be more limited by light than by nutrients (Bonilla et al., 2005).

Climate change was identified as the major environmental driver affecting Arctic freshwater ecosystems (Prowse and Reist, 2013). The duration of freshwater ice cover is strongly controlled by climate. The lake ice-cover duration in the Northern Hemisphere (1846-1995) has declined: freeze-up becomes later, break-up becomes earlier and the ice cover duration has decreased (Prowse et al., 2011). Rivers are also showing the same trend although there are regional differences (Prowse et al., 2011). The accelerated climate warming occurring in the Arctic has major implications for the lake ice cover as well. In Arctic freshwater ecosystems, the duration of ice cover has decreased by almost two weeks over the last 150 years, with earlier break-ups and later freeze-ups (Prowse and Brown, 2010). Hence, lakes with seasonal ice cover have a longer ice-free season while lakes with perennial ice covers are becoming ice free during summer (Prowse et al., 2011). These reductions in lake ice cover duration modify thermal conditions that may lead to enhanced evaporation and, in some cases, the loss of shallow lakes (Prowse et al., 2011). In addition, these conditions can lead to enhanced mixing, making Arctic lakes becoming sinks for contaminants (Prowse et al., 2011). Loss of ice cover will also likely lead to increased methane emissions and expose the biota to an increased level of ultraviolet radiation (Prowse et al., 2011). Apart from climate change, other environmental stressors are increasingly relevant for Arctic aquatic ecosystems such as pollution (point source and long-range atmospheric transport), altered hydrologic regimes related to impoundment and diversion of freshwater, water quality degradation due to enhanced mining, and oil and gas activities, and anthropogenic introduction of invasive species via more transport in the North (Prowse and Reist, 2013).
The Arctic climate is challenging for life. It is characterized by extreme seasonality; air temperature vary from glacial to temperate, the winter polar night is followed by the summer midnight sun, and snow and ice covers fluctuate significantly between seasons. Precipitations are generally low and some particularly and regions are classified as "polar deserts". The climates of specific locations within the Arctic are likely to vary since this is a vast region and specific features such as the topography or the distance to the coast, can influence local conditions (Figure 12). For instance, Alert (located on the northern coastline of Ellesmere Island) is influenced by cold air advection from the Arctic Ocean and the blocking of solar radiation by frequent low clouds and fog, while Eureka (located on the coastline of a fiord on Ellesmere Island but not exposed to the Arctic Ocean) is subject to the rain shadow effect of surrounding mountains (Maxwell, 1981).

The long-term station south of the LIA region, Upernavik (72.78°N, 56.13°W), has a mean daily temperature of -7.1 °C for 1981-2010 (Cappelen, 2011). Also, the drainage basin of Greenland, which include the LIA region, has a mean daily temperature of -21.3°C and a total of precipitation of 182.5 mm (Lucas-Picher et al., 2012). In Greenland, there are sharp differences in temperatures from the coast to the fiords (Cappelen, 2013). In summer, drift ice and cold water along the coast make the fiords warmer places. In winter, the situation is reversed and coastal areas are warmer. Ellesmere Island and the north of Greenland are therefore very cold. Nevertheless, unusual very warm temperatures have been recently recorded, such as a maximum of 20.5°C at Ward Hunt Island (83°N, 74°W) in summer 2008 (Vincent et al., 2009).

While there are no permanent human settlements within the proposed World Heritage Site boundaries, people do live in communities along the fringes of the Last Ice Area. In Canada, the communities of Grise Fiord and Resolute are on the southern fringe of the Last Ice Area, while across Lancaster Sound, the communities of Arctic Bay and Pond Inlet would also be considered adjacent to the LIA. In Greenland, the community

Figure 12. Bioclimate subzones of the circum-Arctic based on the Circumpolar Arctic Vegetation Map. Mean July temperature of zone A is 0-3°C, for zone B, 3-5°C for zone C, 5-7°C for zone D, 7-9°C and for zone E, 9-12°C (CAPP team, 2003). Table 1. Location and climate data for Canadian weather stations located in the LIA region or in its vicinity from 1981 to 2010. Data were obtained from the Government of Canada (Government of Canada, 2013a). Lat.: latitude, Long.: longitude, Temp.: mean daily temperature, Days > 0°C: days with daily maximum temperature > 0°C. Precipitation, rainfall and snowfall are all total. NA: not available.

<table>
<thead>
<tr>
<th>Station</th>
<th>Lat. (°N)</th>
<th>Temp. (°C)</th>
<th>Days &gt; 0°C</th>
<th>Precipitation (mm)</th>
<th>Rainfall (mm)</th>
<th>Snowfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert</td>
<td>82.52</td>
<td>82.28</td>
<td>37.69</td>
<td>80.62</td>
<td>158.29</td>
<td>27.43</td>
</tr>
<tr>
<td>Eureka</td>
<td>79.98</td>
<td>85.93</td>
<td>18.75</td>
<td>98.95</td>
<td>70.07</td>
<td>32.53</td>
</tr>
<tr>
<td>Resolute</td>
<td>74.72</td>
<td>94.37</td>
<td>25.67</td>
<td>92.90</td>
<td>161.20</td>
<td>59.47</td>
</tr>
<tr>
<td>Pond Inlet</td>
<td>72.69</td>
<td>77.97</td>
<td>14.56</td>
<td>119.62</td>
<td>180.01</td>
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<tr>
<td>Igloolik</td>
<td>70.49</td>
<td>68.52</td>
<td>12.58</td>
<td>122.67</td>
<td>63.29</td>
<td>194.74</td>
</tr>
</tbody>
</table>

Snow provides important denning habitat for several Arctic species such as polar bear and ringed seals (Callaghan et al., 2011b). For instance, female ringed seals give birth to their pups from March to June. To successfully rear young, ringed seals in the central Arctic need on-ice snow depths in April of at least 50 cm. Such snow depths are usually found as snow drifts next to sea ice ridges but can be present on flat landfast ice (Hezel et al., 2012). Thus, the period over which snow accumulates on ice is considered to be the primary factor influencing the quality of ringed seal breeding habitat (Smith and Lydersen, 1991). Inadequate snow depths increase pup mortality through exposure and predation (Ferguson et al., 2005).

Snow cover on sea ice controls the underwater light availability by strongly attenuating light penetration. Snow cover influences the timing of the early spring under ice productivity in the Arctic Ocean, since primary production is limited by the growth of ice algae as soon as a critical amount of light reaches the ice-water interface in spring. If the snow cover persists during the summer, it will also reduce the light available for photosynthesis by the phytoplankton. The huge importance of snow cover in attenuating light penetration of ice-covered aquatic ecosystems was demonstrated by a field experiment that removed the snow cover from an area of a perennially ice-covered lake. Removing the snow greatly increased light that was available at the ice-water interface (Belzile et al., 2001). This study also showed the much greater role of the snow cover compared to the ice cover in attenuating light penetration (Belzile et al., 2001).

People of the Last Ice Area

We acknowledge the support of the Government of Canada through the Canada Heritage Fund. The Circumpolar Arctic Vegetation Map project was funded by the Government of Canada, the Natural Sciences and Engineering Research Council of Canada, Environment Canada, and the Province of Ontario.

The Arctic Nomination Project was supported by the Government of Canada through the Arctic Nomination Project. The project was administered by the Canadian Association of Chiefs of Parks (CACP). The Circumpolar Arctic Vegetation Map project was funded by the Government of Canada, the Natural Sciences and Engineering Research Council of Canada, Environment Canada, and the Province of Ontario.

Table 1. Location and climate data for Canadian weather stations located in the LIA region or in its vicinity from 1981 to 2010. Data were obtained from the Government of Canada (Government of Canada, 2013a). Lat.: latitude, Long.: longitude, Temp.: mean daily temperature, Days > 0°C: days with daily maximum temperature > 0°C. Precipitation, rainfall and snowfall are all total. NA: not available.

Snow is an important and dominant feature of Arctic terrestrial landscapes and marine icecapes, with cover present for eight to ten months of the year. Its extent, dynamics, and properties (e.g. depth, density, water equivalent, grain size, and changes in structure throughout its vertical profile) affect climate (e.g. ground thermal regime), human activities (e.g. transportation, resource extraction, water supply, use of land, and ecosystem services), as well as infrastructure, hydrological processes, permafrost, extreme events (including hazards such as avalanches and floods), biodiversity, and ecosystem processes (Callaghan et al., 2011b). Air temperature and precipitation are the main drivers of regional-scale snow cover variability over the Arctic region, with local-scale variability in snow cover related to interactions with vegetation cover and topography through processes such as blowing snow and sublimation (when water changes directly from solid to vapor form without thawing) (Callaghan et al., 2011b). Impurities in the snow (e.g. leaf litter and organic and black carbon) contribute to local (landscape) and regional (circular-Arctic) differences in how much of the sun’s energy is absorbed which influences spring season melt rates (Callaghan et al., 2011b). In contrast to temperate regions, most of the Arctic snowmelt during spring occurs over a very short period of time.

Snow provides important denning habitat for several Arctic species such as polar bear and ringed seals (Callaghan et al., 2011b). For instance, female ringed seals give birth to their young in snow dens on the sea ice. The snow cover provides protection from cold temperatures and predators. These snow dens are especially critical when pups are nursed from late March to June. To successfully rear young, ringed seals in the central Arctic need on-ice snow depths in April of at least 50 cm. Such snow depths are usually found as snow drifts next to sea ice ridges but can be present on flat landfast ice (Hezel et al., 2012). Thus, the period over which snow accumulates on ice is considered to be the primary factor influencing the quality of ringed seal breeding habitat (Smith and Lydersen, 1991). Inadequate snow depths increase pup mortality through exposure and predation (Ferguson et al., 2005).

Snow cover on sea ice controls the underwater light availability by strongly attenuating light penetration. Snow cover influences the timing of the early spring under ice productivity in the Arctic Ocean, since primary production is limited by the growth of ice algae as soon as a critical amount of light reaches the ice-water interface in spring. If the snow cover persists during the summer, it will also reduce the light available for photosynthesis by the phytoplankton. The huge importance of snow cover in attenuating light penetration of ice-covered aquatic ecosystems was demonstrated by a field experiment that removed the snow cover from an area of a perennially ice-covered lake. Removing the snow greatly increased light that was available at the ice-water interface (Belzile et al., 2001). This study also showed the much greater role of the snow cover compared to the ice cover in attenuating light penetration (Belzile et al., 2001).

People of the Last Ice Area

While there are no permanent human settlements within the proposed World Heritage Site boundaries, people do live in communities along the fringes of the Last Ice Area. In Canada, the communities of Grise Fiord and Resolute are on the southern fringe of the Last Ice Area, while across Lancaster Sound, the communities of Arctic Bay and Pond Inlet would also be considered adjacent to the LIA. In Greenland, the community...
of Qaanaaq borders the Greenlandic portion of the Last Ice Area. Indigenous peoples have used this area for thousands of years, with habitation of Ellesemere Island traced back as early as 2000 B.C.E. Current use includes hunting over much of the continental shelves north of Greenland and of the Canadian Arctic Archipelago, part of the LIA, extend for a maximum of 300 km off the coast, up to a depth of around 400 m, until they reach the shelf break (i.e. where the slope is very steep). Water depths in the central Canadian Arctic Archipelago are generally shallow (< 100 m) although Lancaster Sound reaches depths of up to 800 m (Niemi et al., 2010). Fiords on the northern coast of Greenland can be very deep (Petermann Fiord is 1,100 m deep (Johnson et al., 2011)) while fiords located on the north-east coast of Ellesemere Island are not well known, except that Disko Fjord is about 450 m deep (D. Antonaides, pers. comm.).

Currents and surface flows
The circulation of surface waters in the Arctic Ocean flows predominantly from the Pacific to the Atlantic Ocean (Figure 14). The flow to the Atlantic Ocean is through several routes in the Canadian Arctic Archipelago, mainly in Lancaster Sound/Barrow Strait and in Nares Strait, and through Fram Strait, down the east coast of Greenland. The Pacific Ocean water is characterized by a low salinity (less than 33 ‰) and is nutrient-rich compared to the Atlantic Ocean water. The Pacific waters are therefore less dense and form a layer on top of the Atlantic water mass. Freshwater from sea ice melt and river discharges add to this surface layer and contribute to the stability of the water column. A consequence of these high freshwater inputs is the permanent stratification of the central Arctic Ocean with a surface salinity of 32 ‰ and a deep water salinity of 34 ‰ (Gradinger et al., 2010). Surface waters become rapidly depleted in nutrients due to the bloom of its primary productivity but the underlayment layers remain nutrient-rich. The interplay between the winds and the stability of the stratification determine the vertical supply in nutrients by mixing deep waters into the surface layers (upwelling).

Water masses of the Arctic Ocean are found to vary in temperature, salinity and position from year to year. These changes, apart from modifying water stratification and mixing regimes, may affect nutrient concentrations, and the distribution of plankton, fish larvae and larger invertebrates. Arctic marine biodiversity is therefore linked to the dynamic pattern of oceanic conditions (CAFF, 2013b). The wind-driven surface circulation in the Arctic Ocean also determines the movement of sea ice. The clockwise Beaufort Gyre controls the movement of the Arctic pack ice off the northern coast of Greenland and along the northwestern margin of the Canadian Arctic Archipelago (Figure 14). By recirculating ice, the Beaufort Gyre produces the thickest and oldest ice in the Arctic Ocean (Lee et al., 2012). Moreover, the Transpolar Drift moves ice from the Siberian coast region across the Arctic Ocean towards and eventually through Fram Strait (National Snow and Ice Data Centre, 2013a). As a result, on a basin-scale, the thickest sea ice (mean thicknesses of 4 to 6 m) is located off the northern coast of Greenland and along the northwestern margin of the Canadian Archipelago, and is the region covered by the LIA project.
Sea ice is frozen ocean water and it is found throughout the Arctic and around the Antarctic. Different types of sea ice are found and they have distinct properties (Figure 15, 16). First-year ice is floating ice of no more than one year’s growth. Its thickness ranges from 0.3 to 2 m. This ice type is generally level but ridges that occur are rough and sharply angular (National Snow and Ice Data Centre, 2013a). As sea ice forms, it expels salt into the ocean water by the formation of brine (droplets of high-saline water) that is trapped in pockets between the ice crystals. Another way that salts are expelled on new seasonal ice is by the forming of frost flowers on top of it (Barber et al., 2012a). When sea ice becomes multi-year ice (ice that has survived at least two summer melt seasons (Parkinson and Comiso, 2013)), it becomes fresh as the salts have been expelled and all that remains is frozen water. Multiyear ice is therefore stiffer and it is harder for icebreakers to navigate through it (National Snow and Ice Data Centre, 2013a). Extensive multi-year ice forms in the Arctic Ocean as it is land-locked back to space. Areas of open water absorb more solar energy and contribute to further warming and more sea ice melt. This process contributes substantially to the Arctic amplification of climate change. Sea ice also affects the movement of ocean waters. When sea ice forms, brine is pushed into the ocean water just underneath the ice. This water has a high concentration of salt and is denser than surrounding ocean water, thus sinks. By this process, sea ice contributes to the ocean’s global thermohaline circulation (Figure 18). Changes in the amount of sea ice formed can disrupt normal ocean circulation, thereby leading to changes in the global climate. In contrast, when the sea ice cover melts in the Arctic Ocean or in Fram Strait, it creates a layer of freshwater on top of the ocean water. Since freshwater is less dense than seawater, it tends to stay at the top of the ocean. This lower density discourages the normal process of sinking at high latitudes that supports the thermohaline circulation. Ice cover also controls atmosphere-ocean exchanges. It isolates the upper ocean from direct wind forcing which physically protect the surface water from mixing and damps surface wave motion. Ice cover also protects the coasts from erosion by bigger wave heights leading to
greater coastal erosion and recessions. It also serves as an efficient thermal insulator. The Arctic’s atmosphere is very cold during the winter while the ocean is relatively warm during the summer. Heat can escape from leads and polynyas. As the ice melts, energy and moisture move out of the ocean to the atmosphere resulting in more storms such as cyclones (cells of air that rotate in a counter-clockwise direction), characterized by high winds and precipitation.

The sea ice cover also plays important roles for the Arctic marine ecosystem. Similar to the snow cover, the ice cover influences how much light will penetrate to the under-ice ecosystems and affects the timing and extent of ice algal productivity (Arrigo et al., 2012). The different components of Arctic marine biodiversity use and depend on sea ice in different ways. Sea ice is the substrate for organisms that thrive within it (see section Biodiversity in the sea ice). Some features of the sea ice environment are of particular ecological significance since they are highly productive: marginal ice zones, flaw leads and polynyas (Figure 19).

MARGINAL ICE ZONES, FLAW LEADS AND POLYNYAS

Some features of the sea ice environment are of particular ecological significance since they are highly productive: marginal ice zones, flaw leads and polynyas (Figure 19).

Marginal ice zones

The marginal ice zone is the transition area from ice-covered seas to open water, where sea ice is significantly influenced by the action of waves. Waves are responsible for the break-up of ice floes (drifting pieces of sea ice) and determine the extent of the marginal ice zone. They represent narrow zones that are 25–100 km wide (Dumont et al., 2011). These areas are complex and variable sea ice environments. Swells and waves are lower as they enter the marginal ice zone. Typical marginal ice zone conditions are found along the southern edges of the ice pack in the Bering, Greenland, Chukchi, and Barents Seas, and in Baffin Bay (Lachlan Ramsay et al., 1981). Marginal ice zones are recognized as biologically productive regions, where large numbers of phytoplankton, zooplankton, seabirds and marine mammals congregate. In the Arctic, this is due to upwelling occurring at the sea-edge (Smith et al., 1987). Upwelling is the process by which deep, nutrient-rich waters rise to the surface due to the action of the winds or currents. Arctic surface waters are typically reduced in nutrient concentrations and the water column is highly stratified, which limits the growth of phytoplankton. Upwelling, created by the action of the wind on the open water, inject nutrients into the surface waters.

A significant implication of the recent decrease in sea ice extent has been the retreat of the ice edge away from the coast and continental shelves (Lee et al., 2012). At the end of the summer, when sea ice extent reaches its minimum, the marginal ice zone is located above the deep ocean which was until recently perennially ice covered (Lee et al., 2012). As an example, the recent decrease in sea ice extent has resulted in the production of a substantial marginal ice zone in the deep Beaufort Sea (Lee et al., 2012). Extending open water conditions in the marginal ice zone permit more direct connection with the atmosphere and can have implications for the upper ocean structure and sea ice evolution. The LIA as described in Figure 6 does not include marginal ice areas but these areas will be increasingly present in the LIA as sea ice extent decreases.

Flaw leads

Flaw leads are areas of unconsolidated ice or ice-free waters between the mobile multiyear pack ice and the fixed coastal fast ice (Dimeng and Fortier, 2011). The circumpolar flaw lead is a perennial feature of the Arctic observed throughout the winter (Figure 20). It consists in a large crack in the ice at the periphery of the Arctic Ocean, along the coastlines of the shallow seas that surround the deep Arctic Ocean basins (Dimeng and Fortier, 2011). The circumpolar flaw lead in the LIA area is relatively narrow since multiyear landfast ice is still substantial in this area even during the summer. In some areas, the circumpolar flaw lead widens significantly in spring and summer and forms recurrent polynyas where biological productivity is increased (Dimeng and Fortier, 2011). Flaw leads are also areas of high ice production (Dethlef et al., 1998).

The ice edges of a flaw lead are areas of high biological productivity (Barber et al., 2012a). Upwelling is caused by strong winds which mixes water layers and introduces deeper water replete with nutrients close to the surface, making them available for biological growth (Barber et al., 2012a). As the sea ice cover and volume are decreasing with a warming climate, the open-water season at the periphery of the Arctic Ocean is lengthening and the circumpolar flaw lead is projected to enlarge and to last longer (Dimeng and Fortier, 2011). Ecosystem-wide enhancements in productivity are expected in these areas (Barber et al., 2012a).

Polynyas

Polynyas are large areas (10 – 90,000 km2) of permanently or frequently open water surrounded by thick ice (Barber et al., 2001b). Polynyas are generated by warm water input from below or by the action of strong winds that move away sea ice as soon as it is formed (Barber et al., 2001a; Tremblay and Smith Jr, 2007). Similar to the flaw leads, polynyas produce a lot of sea ice.

Polynyas are highly productive areas and hotspots of diversity compared to other ice-covered areas of the Arctic Ocean.
The largest polynya in the LIA region is the North Water Polynya (NWP) in northern Baffin Bay between Canada and Greenland (Figure 21). This polynya forms each spring and is the largest and most productive recurring polynya in the Arctic (Deming et al., 2002; Dumont, 2012). Its formation is due to a combination of factors: strong northerly winds blow the ice downstream of an ice bridge that forms at the construction point between Baffin Island and Ellesmere Island, leaving an area of open water (Dumont et al., 2010). The former Northeast Water polynya (NEW), off the northeast coast of Greenland, is no longer considered a polynya due to changed ice conditions (Kovacs and Michel, 2011). The NEW polynya was only moderately productive due to little replenishment of nutrients (Schneider and Budeus, 1995). Several polynyas smaller than the NWP can be found within the LIA region (Niemi et al., 2010). Polynyas are dynamic features that vary in timing, extent and duration from year to year (Dumont et al., 2012). Moreover, a warmer climate associated with a reduction in thick sea ice cover may affect polynyas in different ways, although it is expected that they will more commonly decrease in duration (Smith Jr and Barber, 2007). For instance, trends over the last 4 decades show that the NWP polynya is occurring less frequently and break-up earlier. Also, its formation is due to the presence of thick sea ice and a slightly warmer Arctic winter could lead to its demise (Dumont, 2012). In contrast, the Wangel Island polynya, located in the Chukchi Sea, has more than doubled in extent over the last 30 years (Moore and Pickart, 2012). New polynyas could be generated at other sites (Ingram and Carmack, 2006). Species reliant on polynyas will need to adapt where they go and if they are to remain connected to these areas. Alternatively, they will have to adapt to less productive habitats (Ingram and Carmack, 2006).

Ice shelves. Ice in bays and fiords can become very thick since less dynamic conditions in wind and current, compared to offshore, have permitted ice growth over periods lasting from tens to thousands of years. Ice shelves are defined as thick (>10 m) ancient ice attached to the coastline (multiyear landfast sea ice) and floating on the sea (Vellotte et al., 2008). Ice shelves are in hydrostatic equilibrium with the ocean and hence, only 10% of their total thickness is emerging above sea level (Freeboard) (Mortimer, 2011). Ice shelves are a dominant feature of the Antarctic, where they border 55% of the coastline (Wingham and Rottgers, 2003). Ice shelves provide the physical structure for unique ecosystems. Cold-tolerant microbial communities occur in association with sediments on the ice shelves’ surface (Mueller et al., 2006). The surface morphology of ice shelves is characterized by undulations parallel to the coast that would be caused by the alongshore winds (Hattermann and Smith, 1997). During the summer, meltwater flows in the troughs of these undulations and creates large lakes (up to 15 km), thin (10-20 m), and shallow lakes (maximum of 3 m).

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that are also characterized by their microbial mat communities (Mueller et al., 2006). DNA profiling demonstrated that the mat microbial communities were composed of all three domains of life (Bacteria, Archaea and Eukarya) and viruses (Varin et al., 2010, 2012). Moreover, when an ice shelf completely dams a fiord or an embayment, a lake called “epishelf” may be formed on the landward side (Veillette et al., 2008). These ice-dammed lakes are highly stratified since a layer of freshwater from snow and ice melt floats on top of sea water. These waters do not mix because of their different densities, and because the perennial ice cover stops wind from mixing them (Veillette et al., 2008). There is currently only one known remaining Arctic epishelf lake, in Milne Fiord (Veillette et al., 2011). Ice shelves and their associated epishelf lakes are vulnerable Arctic ecosystems that have become extremely rare and will likely become extinct in the coming decades (Veillette et al., 2011).

MARINE BIODIVERSITY

The Arctic Ocean provides diverse habitats for a multitude of unique life forms highly adapted in their life history, ecology and physiology to the extreme and seasonal conditions of this environment. The logistical challenges imposed by the harsh Arctic environment limit our knowledge of the marine biodiversity. This is especially true for the High Arctic where biological data are sparse and almost nonexistent for some habitats (e.g. the benthos) (Piepenburg et al., 2011).

Arctic marine food webs and productivity

Arctic marine food webs comprise the interconnections between microbes, algae and animals (Figure 25). Primary producers (ice algae and phytoplankton) support the base of the Arctic marine food web. They convert the energy from the sun into food energy. Then, zooplankton, such as copepods, and bacteria graze on these primary producers. In turn, carnivorous zooplankton, fish (Arctic cod) and whales feed on zooplankton. Arctic cod are the main food source of seals. Top predators such as humans, polar bears, seals and whales are then generally feeding on a combination of different species. Detritus, which typically includes the bodies or fragments of dead organisms as well as fecal material and nutrients, sink to the sediments where they support invertebrates and microbial communities. The relatively short growing season implies that consumers have a narrow window of opportunity to grow and accumulate energy reserves for winter survival and/...
or reproduction. Arctic marine food webs involve numerous pathways but are not considered complex compared to the food webs of more temperate systems. These food webs are considered vulnerable to perturbations (de Santana et al., 2013).

Primary production

Primary production determines the amount of food that is available to consumers. Also, primary producers, by fixing the greenhouse gas CO₂, help to reduce its burden in the atmosphere since sinking algæ and detritus remove carbon from the surface waters (a process known as the biological pump). Primary production in the Arctic Ocean depends on light and nutrients (i.e. nitrate is usually limiting). It starts with the growth of ice algæ as soon as a critical amount of light reaches the ice-water interface in spring. Since snow attenuates light penetration, it influences the timing of ice algæ growth. Ice algæ production then boosts the ice-algæ synthesis. At the onset of ice melt, fat-rich ice algæ are released in the water column and provide high energy food for the zooplankton, and eventually to the seafloor, at a time when little food is available (Tremblay et al., 2012). Phytoplankton then take over as the dominant primary producers. The intensity of the late spring or early summer phytoplankton bloom is controlled by the availability of nutrients, which are readily depleted from the surface layer. The surface layer derived from ice melt is relatively less dense and restricts the mixing with nutrient-rich waters from deeper waters. The primary production declines during summer and until the ice forms in the fall. A second bloom can occur in polyynas where ice growth is delayed (Tremblay and Smith Jr, 2007).

This classical view of the annual cycle of primary productivity in the Arctic Ocean, presented in the above paragraph, is challenged by some works that report phytoplankton blooms under the ice cover over continental shelves in Barrow Strait in the Canadian Arctic Archipelago compared to other oceanic environments located at lower latitudes (Nieni et al., 2010). This is explained by the reduced availability of light since the sun is up only during the summer and the sea ice cover controls the amount of light that reaches the water column. Snow on the ice cover also contributes to reduce light penetration. Primary productivity is also extremely variable among different areas of the Arctic Ocean. Figure 26 illustrates the depth integrated primary production from 1998 to 2007. Depth integrated primary production is used since vertical profiles of primary production at many sites in the Arctic Ocean revealed persistent surface peaks during most of the summer period (Hill et al., 2013). Coastal seas account for 75% of annual integrated primary production while the central basin and Beaufort northern seas were the regions with the lowest annual integrated productivity due to persistently stratified, nutrient-depleted and ice-covered conditions. The highest primary production is located in the northern Bering Sea and southern Chukchi Sea, and this is explained by the more nutrient-rich waters of the Pacific Ocean compared to the Atlantic Ocean. The overall LIA region is moderately productive with the NOW polynya being a hotspot of primary productivity (Figure 26). This variation in primary productivity in the Arctic Ocean is influenced by latitude, seasonal and multiyear ice sea and snow cover, latitude of the surface mixed layer, discharge of inorganic sediments (causing light attenuation) and nutrients from rivers and water circulation patterns (Gosselin et al., 1997; Pabi et al., 2008). Ice algæ contribute around 60% of the entire primary production (sea ice and water column) in the central Arctic Ocean but only 3% in the coastal seas (Gosselin et al., 1997). However, primary productivity within and under the sea ice may increase with higher light transmission through thinning sea ice (Boeius et al., 2013). Primary productivity in the coastal seas and in the deep central basin are also very different in terms of timing and composition (Tremblay et al., 2012).
A recent pan-Arctic assessment of marine phytoplankton reported two distinct developmental types (Poulin et al., 2011). This number is indicative of a well-diversified group of organisms (Poulin et al., 2011). Pinnate and centric diatoms, diatomagellates and diatoms are the most frequently reported marine phytoplankton groups in the Arctic (Poulin et al., 2011). The vast majority of the identified microorganisms consist of large cells (>20 μm) because of the magnification capability of light microscopy. Recent major technological advances in molecular biology permitted identification of most major groups of marine microbes in the three domains of life (Bacteria, Archaea and Eucarya) in Arctic marine waters (Lovejoy et al., 2011). Communities of phytoplankton change dynamically with the seasons (Terrado et al., 2009).

Climate change has already had impacts on phytoplankton communities. The warming and freshening of the surface layer lead to increased stratification and nutrient depletion. Small picoplankton, being very small (<2 μm diameter), have a large surface area to volume ratio that provides effective acquisition of nutrients as well as hydrodynamic resistance to sinking. Hence, these small cells are thriving and displace the larger cells (Li et al., 2009). Increased ice-free conditions may favour and extend northwardly the intrusion of Atlantic water and promote phytoplankton migrations to depths of several hundred meters where the late development of phytoplankton species (Hegseth and Sundfjord, 2008). An inventory of benthic species colonizing the central Arctic shelf zone, and the deep sea with several basins separated by deep sea ridges (Josefson and Moiklevsky, 2013). At smaller scales, benthic areas contain different sediment habitats such as sand and mud as well as hard substrates like boulders and beds. Nearshore areas are affected by ice scouring and present impoverished benthic diversity. Macrourae (sea mammals) are found in shallow waters.

Much remains unknown about what species are found in the Arctic benthos, particularly in deep water, where new species are still being described and where half of the species were observed at only one or two locations (Bluhm et al., 2011a). An inventory of benthic communities in the central Arctic deeper than 500 m resulted in 1,125 species (Bluhm et al., 2011a). Crustaceans, foraminifers, annelids and nematodes dominate benthic diversity. A recently identified species (large enough to be retained on sieves with a mesh size of 0.5 mm, mostly fauna that live in the mud) and megafauna (larger than 1 cm, mostly live on the surface of the substrate and are visible on seafloor images) colonizing the seafloor of Arctic shelves suggest an intermediate biodiversity due to a combination of anticipated increased food availability and immigration of faster-growing species. Arctic benthos ranges from unicellular life in the spaces among sediment particles to large invertebrates (Figure 2). The Arctic seafloor presents a multitude of habitats that include intertidal areas, floods, estuaries, an expanded shelf zone, and the deep sea with several basins separated by deep sea ridges (Josefson and Moiklevsky, 2013). At smaller scales, benthic areas contain different sediment habitats such as sand and mud as well as hard substrates like boulders and beds. Nearshore areas are affected by ice scouring and present impoverished benthic diversity. Macrourae (sea mammals) are found in shallow waters.

It is expected that the benthic fauna may show increased biodiversity, due to a combination of anticipated increased food availability and immigration of faster-growing species, adapted to warmer waters in the southern areas of the Arctic (Josefson and Moiklevsky, 2013). Moreover, fisheries of commercially relevant species might become more important in the LIA. Commercial shrimp fisheries for Northern Pandalus borealis and striped Pandalus montagui shrimp began in the late 1970s off Baffin Island and expanded southward to the area of Resolution Island (Hudson Strait) in the mid-1990s, where the main fishery remains to date (DFo, 2008). The snow crab fishery is the most important marine resource in Greenland, and represents 70% of the total fisheries revenues (Dahl-Jensen et al., 2011). The snow crab fishery is also important in Greenland (Boertmann et al., 2009).

Nearby 250 marine fish species are known from the Arctic Ocean, but this number rises to 633 fish species if the adjacent Arctic seas are included (Christiansen and Reist, 2013). These 633 species represent 2.2% of the fish species on the Arctic shelves.
Seabirds are birds that frequent coastal waters and the open ocean. Loons, petrels, cormorants, jaegers, skuas, gulls, terns and auks are all seabirds. Seabirds are important components of Arctic ecosystems, and are culturally and economically important for local communities. They are also frequently used as indicators of environmental changes. The Arctic is an important region for seabird diversity. Forty-four species of seabirds breed in the Arctic, and forty-one in the Low Arctic. Fifteen species have a circumpolar distribution. West Greenland (24 species) and eastern Canadian Arctic (Northeast Greenland and Queen Maud Land, 22 species), are recognized as biodiversity hotspots (Gaston, 2011). Many seabirds are very conservative in their breeding sites. The 42 species can be found within LIA.

Large breeding colonies of seabirds can be found on cliffs and islands, and some are associated with highly productive areas such as the North Water Polynya. Major breeding seabird colonies of the Canadian portion of LIA include Prince Leopold Island (murrets, kittiwakes, fulmars and guillemots), Coburg Island (thick-billed Murres and Black-legged Kittiwakes), Cape Hay and Cape Graham on Bylot Island (thousands of seabirds and gulls), Hell Gate and Cardigan Strait (Black Guillemot, Northern Fulmar, Common Eider), eastern Devon Island (Ivory Gull, Glaucous Gull colonies), Hobhouse Inlet on Devon Island (Northern fulmar), Cape Liddon and Radstock Bay on Devon Island (Northern fulmar), Ballille-Hamilton Island (Black-legged Kittiwakes), and Browne Island (Black-legged Kittiwakes) (Figure 30). Breeding seabird colonies are present in northwest Greenland (Figure 30), Melville Bay (just south of the community of Arviat) and in detail for breeding seabird colonies and this area revealed low density of breeding colonies and low numbers of breeding seabirds and gulls (Gaston, 2011). Most Arctic seabirds have large population sizes and many species are represented by millions of individuals (Gaston, 2011). For example, the ivory gull has an iconic seabird that inhabits the Arctic Ocean throughout the year, with less than 12,000 breeding pairs globally (Gilchrist et al., 2008). However, most Arctic seabird populations have shown declining trends in recent years (Gaston, 2011). Stresses to Arctic seabirds include overharvesting, fisheries activities, pollution and climate change (Gaston, 2011). The contribution of climate change to the decline in population...
trends is generally linked to the food chain as seabirds rely on ice edges and polynyas as key foraging locations (see references in Gantner and Gaston, 2013). The timing of breeding initiation with seasonal peak food (mainly fish and invertebrates) is influencing the reproductive success. Changes in sea ice cover conditions also allow northward spread of predominantly temperate or Low Arctic species (see references in (Ganter and Gaston, 2013)) at the expense of High Arctic species. Sea ice is also used as a platform for social activities and to escape from marine predators and for resting.

**Marine mammals**

Seven marine mammals species (three whales, three pinnipeds (fin-footed marine mammals) and polar bears) live in the Arctic all year long and many other species occupy Arctic waters seasonally. Arctic marine mammals use several specific types of ice habitats and feed on diverse food sources (Table 2). Changes in the Arctic climate may challenge the adaptive capacity of these species. Sea ice plays a crucial role for these animals either as platform, marine ecosystem foundation and barrier to non-ice-adapted marine mammals and human commercial activities (Moore and Huntington, 2008). A clear example is that reduction in sea ice cover removes the hunting platform of polar bear and likely reduces the survivorship of its primary prey, the ringed seal. The fitness of Arctic marine mammals is therefore influenced by sea ice effects on ecosystem structure and prey availability.

One approach to quantify marine mammal resilience to climate change is to classify them in regard to the species relationship to the ice (Moore and Huntington, 2008). Polar bear, walrus, bearded seal and ringed seal are classified as ice-obligate species since they are reliant on sea ice as a platform for resting, breeding or hunting. Harp seal, hooded seal, ribbon seal, spotted seal, beluga, narwhal and bowhead whale are ice-associated species since they are adapted to marine ecosystems of which ice is predominant. Fin, minke, humpback, gray and killer whales are seasonally migrant species that encounter sea ice in parts of their migration. Ice-obligate species are especially vulnerable to changes in the sea ice cover. The scenario for ice-associated species is harder to predict but decreases in the sea ice cover will have negative impacts on these species, except perhaps reduced risk of sea ice entrapment. The five migrant whale species are likely to benefit from loss in sea ice since the pelagic system will be more accessible.

Another approach to assess the sensitivity of marine mammals to climate change is to use an index that...
includes the species narrowness of distribution and special-
cization of feeding in addition to the seasonal depen-
dence on sea ice and reliance on sea ice as a platform to
access prey and predator avoidance (Laidre et al., 2008).
This index suggests that the hooded seal, the polar bear,
and the narwhal are the three most sensitive Arctic ma-
rine mammal species, primarily due to reliance on sea ice
and specialized feeding. The least sensitive species were
the ringed seal and bearded seal, primarily due to large
circumpolar distributions, large population sizes, and
flexible habitat requirements.

Overall, climate change is forecast to have serious nega-
tive impacts on Arctic marine mammals by altering the sea-
sonal patterns, extent and the quality of sea ice habitat.
Species seasonally occupying the Arctic might stay north
longer, and compete for food resources with existing Arc-
tic species. Also, temperate marine mammals are expanding
their distribution northward, which is likely to cause com-
petitive pressure on Arctic endemic species and to put them at
greater risk of predation, disease and parasite infections
(Kovacs et al., 2011).

Since the LIA is predicted to hold the last remaining ice
during summer, the area is considered likely to become in-
creasingly important for ice-obligate and ice-associated
marine mammal species. This is why WWF is in discussion
with Inuit and governments located in the LIA region in
order to plan the future management of this area to help
ensure the resilience of all life forms dependant on sea ice.
This need has been recognized by the Arctic’s pre-eminent
intergovernmental forum, the Arctic Council. A recommen-
dation of the Arctic Biodiversity Assessment (CAFF, 2013a)
states the importance of developing and implementing
mechanisms to conserve Arctic biodiversity under the de-
teriorating trend of sea ice, glaciers and permafrost.

Whales

Only three whale species live year round in the Arctic (as de-
fined by the boundary developed by the Arctic Council’s work-
ning group, the Conservation of Arctic Flora and Fauna). These
are the bowhead whale, a large baleen whale, and the narwhal
and the beluga, which are middle-sized toothed whales. The
bowhead whale and the beluga have a circumpolar distribu-
tion while the narwhal only occupy the Atlantic sector of the
Arctic (Figure 36; Reeves et al., 2013). Thirteen other whale
species (baleen whales: blue, fin, sei, humpback, minke, North
Atlantic right and gray whales; toothed whales: sperm, Sow-
erly’s beaked and killer whales, Atlantic white-sided
and white-beaked dolphins, and harbour porpoise) seasonally oc-
cupy Arctic and Subarctic waters. The loss of summer sea ice
cover is allowing an increasing number of killer whales to use
the Canadian High Arctic as a hunting ground (Darnis et al.,
2012). The stronger presence of this apex predator species
will likely affect the populations of the bowhead whale, the
narwhal and the beluga. The three Arctic whale species are
described in the following paragraphs.

Bowhead whales (Balaena mysticetus) measure between
15 and 18 m in length and weigh up to 100,000 kg. They live in Arctic
waters during summer but migrate to Subarctic seas dur-
ing winter (Laidre et al., 2008). This whale species occurs
within the LIA region in Baffin Bay and on the eastern side
of the Canadian Arctic Archipelago (Figure 36). The global
population size of bowhead whale would be over 20,000 in-
dividuals. The pre-whaling population of bowhead whales has
been estimated at about 50,000 individuals (COSEWIC, 2009).
Commercial whaling ended around 1910 having re-
duced the population to less than 3,000 animals. The bow-
head whale is listed as “least concern” on the IUCN Red List,
since the population appears to be increasing (Reilly et al.,
2012). This whale species is well adapted to ice-covered wa-
ters and can move through areas of nearly solid ice cover. They
prefer areas of low ice coverage in winter, presumably
to reduce risk of ice entrapment while remaining within the
ice (Ferguson et al., 2010). In contrast, during summer,
these whales select high ice coverage regions to reduce risk
of killer whale predation while providing enriched feeding
opportunities (Ferguson et al., 2010). Bowhead whales also
inhabit polymyx and the marginal ice zone during winter and
early spring (Laidre et al., 2008). The bowhead whale is
feeding on zooplankton throughout the water column in-
cluding near the bottom (Laidre et al., 2008).

Belugas (Delphinapterus leucas) or white whales occur in
estuaries, on the continental shelves and in deep ocean ba-
sins. They measure between 4 and 6 m in length and weigh
between 900 and 1,300 kg. Belugas are divided in discrete populations
around the Arctic, depending on their summering (fiords or estuaries) to
which they show high fidelity (shallow or coastal areas) grounds (see references in
Laidre et al., 2008; Figure 36). DNA studies have indicated genetic
differences between some of the populations (de March and
Postma, 2003). The world wide population estimate is well
over 150,000 animals and has been divided into 29 different
populations (or stocks) by the International Whaling Com-
mission (Jefferson et al., 2012a). This species is listed as
“near threatened” on the IUCN Red List because there is large
uncertainty about population numbers and trends over parts
of the species range, and because its survival relies on na-
tional and international conservation programs that monitor and manage hunting (Jefferson et al., 2012a). The different populations of belugas are subject to different levels of threat which call for individual assessments (Jefferson et al., 2012a). Two populations are present within the LIA for at least parts of the year: the North Water winter (North Baffin Bay) stock, with an estimated population size of 21,213 belugas based on 1996 surveys (Innes et al., 2002) and the West Greenland winter stock, with an estimated population size of 7,941, based on 1998 and 1999 surveys (Heide-Jørgensen and Aquarone, 2002). Ice edges serve as important feeding grounds for belugas as their predominant prey is Arctic cod.

Narwhals (*Monodon monoceros*) are medium sized (4 to 6 m, 1,600 kg) toothed whales that occupy waters of the eastern Canadian Arctic Archipelago, West and East Greenland, Svalbard and Franz Joseph Land (Figure 36). They are widely present in the LIA region. It is the Arctic whale with the most restricted distribution. Narwhals perform annual migrations over long distances. During summer, narwhals spend approximately two months in High Arctic ice-free shallow bays and fiords. They overwinter in offshore, deep, ice-covered habitats along the continental slope in more southern locations (Heide-Jørgensen and Dietz, 1995). Narwhals feed mainly during winter on benthic organisms and Greenland halibut in offshore deep ocean basins (Laidre et al., 2008). The narwhal is listed as “near threatened” on the IUCN Red List, although there is uncertainty about numbers and trends in large parts of the species range and evidence of decline for specific subpopulations (Jefferson et al., 2012b). The total population is greater than 80,000 individuals (Jefferson et al., 2012b). Narwhals are the most ice-associated whales: they are found in dense pack ice and are highly dependent on leads and cracks in the ice during migrations (Laidre et al., 2008).

Pinnipeds
Arctic ice-obligate pinnipeds with a circumpolar distribution are the ringed seal, the bearded seal and the walrus (Laidre et al., 2008). Other seal species that can be found in Arctic waters are the spotted seal, the common seal, the harp seal and the hooded seal (Greenland Institute of Natural Resources, 2012; Laidre et al., 2008). These latter species depend on sea ice only for some parts of their life cycle, especially for birthing, molting, mating and resting during spring. In contrast to Arctic ice-obligate species, they are not year round in the Arctic and they rely on sea ice only seasonally. The ribbon seal and the spotted seal only occur in the Bering, Chukchi and Okhotsk seas while the common seal, the harp seal and the hooded seal occur only in the North Atlantic (Greenland Institute of Natural Resources, 2012; Laidre et al., 2008). The three Arctic ice-obligate seal species found year round in the Arctic occur within the LIA region, but only ringed seals are reported to occur along the northern coastline of the Canadian Archipelago and Greenland (Figure 37). These are briefly described in the next paragraphs.

The ringed seal (*Pusa hispida*) is the most common and widely dispersed marine mammal of the Arctic. It is the smallest of the seal species (up to 1.65 m and up to 70 kg) and they get their name from the light-coloured circular patterns that appear on their darker grey back. The species has a circumpolar distribution (Figure 37).
Ice provides a platform on which the seals haul out, bear nurse pups, and rest and moult. Bearded seals feed primarily on benthic organisms that include epifaunal (are attached to substrates) and infaunal (live in the substrate/soft sea bottom) invertebrates and demersal fishes (fish that live near the seafloor). Polar bears and walruses are the main predators of bearded seals (LaRue et al., 2008).

Walruses (Odobenus rosmarus) is the largest species of pinniped in the Arctic, measuring between 3.0 and 3.6 meters and weighing between 600 and 2,000 kg. Walruses have a discon- tinuous circumpolar Arctic and Subarctic distribution. Walruses are benthic feeders and shallow divers; they feed mainly on ringed and bearded seals (Laidre et al., 2008). Nevertheless, the Atlantic population would be between 3 and 8 millions but certain. Only the Atlantic subspecies is found within the LIA. The population estimates that are available have a low preci- sion (Lowry et al., 2008). The walrus was once threatened by commer- cial hunting but today the biggest danger it faces is climate change. The walrus is listed under the category of “data defi- cient” in the IUCN red List (Lowry et al., 2008).

Polar bears are an iconic Arctic species. They are considered marine mammals because they live predominantly on the sea ice throughout the Arctic. They are the main predators of various archipelagos. Polar bears prefer to forage on sea- sonal sea ice but will also use multiyear sea ice. In more southern locations, such as Hudson Bay and Davis Strait, where annual ice melts completely, bears spend up to sev- eral months on land waiting for the ice to freeze again. Polar bears have annual movement patterns within their home ranges and they show high fidelity to denning and spring feeding areas (LaRue et al., 2008; Lone et al., 2013). Sea ice also facilitates, but is not essential, for seasonal move- ments, mating, and in some cases, maternal denning (LaRue et al., 2008). They feed mainly on ringed and bearded seals but they also eat belugas, narwhals and walruses (LaRue et al., 2008). They also feed on land, eating eggs, berries, and whatever they can scavenge.

The worldwide polar bear population is divided into 19 subpopulations (Figure 42) and four ecological regions have been described (Figure 43; Amstrup, 2011). This spe- cies is listed as “vulnerable” on the IUCN Red List with an estimated global number of 20,000 to 25,000 (Schliebe et al., 2008). In 2008, the polar bear was listed as Special Concern under the Federal Species at Risk Act of Canada (Government of Canada, 2012c). Out of the 19 subpopu- lations, four are considered to be declining in numbers (IUCN PBG 2013). The main threat to the polar bears long-term survival is the loss of sea ice habitat (Stirling and Derksen, 2012). The critical feeding time occurs in late spring and early summer, when they feed on ringed seal pups that are born in early April and weaned about six weeks later. At that time, pups are up to 50% fat, naïve about predators and various archipelagos. Polar bears prefer to forage on sea- seasonal sea ice but will also use multiyear sea ice. In more southern locations, such as Hudson Bay and Davis Strait, where annual ice melts completely, bears spend up to sev- eral months on land waiting for the ice to freeze again. Polar bears have annual movement patterns within their home ranges and they show high fidelity to denning and spring feeding areas (LaRue et al., 2008; Lone et al., 2013). Sea ice also facilitates, but is not essential, for seasonal move- ments, mating, and in some cases, maternal denning (LaRue et al., 2008). They feed mainly on ringed and bearded seals but they also eat belugas, narwhals and walruses (LaRue et al., 2008). They also feed on land, eating eggs, berries, and whatever they can scavenge.
accessible from the surface of the ice. After the ice break-up, seals are mostly inaccessible to the bears. A reduced extent in sea ice and an earlier ice break-up in spring results in less time to access prey, longer periods of fasting, less healthy body condition and lower survival of cubs in the past, the adaptive capacity of polar bears is limited since they are highly specialized for life in the Arctic, and they exhibit low reproductive rates with long generational spans. Moreover, the pace of Arctic sea ice habitat loss may be too fast for polar bears to adapt. Projections of polar bear species have adapted to changes in their environment and if climate warming continues, a research team argued that polar bear could disappear from two-thirds of their current global habitat by 2050 (Amstrup et al., 2008). The LIA is likely to be a large chunk of remaining prime habitat. A global coordinated monitoring framework of polar bear subpopulations is proposed as this would provide a better circumpolar understanding of ongoing patterns and future trends in polar bear subpopulations, and would improve the monitor of the effects of stressors on polar bears (Vongraven et al., 2012).

LIA is home to six polar bear subpopulations (Table 3). The populations of Baffin Bay and Kane Basin are held responsible for this decline and an agreement between both parties signed in 2009 should help making harvest sustainable (CBC news, 2009). Within LIA, thick multiyear ice will be replaced in the LIA region (data are from Vongraven and Richardson, 2011). Table 3. Numbers and trends of the polar bear subpopulations found in the LIA region (data are from Vongraven and Richardson, 2011).

<table>
<thead>
<tr>
<th>Subpopulation</th>
<th>Number (year of estimate)</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baffin Bay (BB)</td>
<td>1546 (2004)</td>
<td>Decline</td>
</tr>
<tr>
<td>Kane Basin (KB)</td>
<td>164 (1998)</td>
<td>Decline</td>
</tr>
<tr>
<td>Northern Bay (NB)</td>
<td>200 (1998)</td>
<td>Decline</td>
</tr>
<tr>
<td>Lancaster Sound (LS)</td>
<td>2541 (1998)</td>
<td>Decline</td>
</tr>
<tr>
<td>Arctic Basin</td>
<td>Unknown</td>
<td>Data deficient</td>
</tr>
<tr>
<td>East Greenland (EG)</td>
<td>Unknown</td>
<td>Data deficient</td>
</tr>
</tbody>
</table>

The terrestrial environment

The LIA is composed of many landscapes. Towering mountains with peaks over 2,000 m are found in the eastern islands of the Canadian Arctic Archipelago (Ellesmere, Axel Heiberg and Devon). The higher land on these islands is commonly covered by ice caps. Spectacular fiords and glaciers are also part of the landscape. The central and western islands of the

Figure 42. Map of location, size and trends of polar bear subpopulations.

Figure 43. Ecoregions used in analysis of the future global status of polar bear. Ecoregions include the 19 Polar Bear management units (black letters) as defined by the IUCN Polar Bear Specialists Group, and blue lines represent general ice flow patterns (Amstrup, 2011).
The Arctic contains an abundant and wide range of fresh- water ecosystems, including lakes, rivers, ponds, streams and a complex array of wetlands and deltas. These aquatic environments are habitats for diverse biological communities (see section Aquatic biodiversity) and are important for human use and as carbon reservoirs. They also provide drinking water supplies to communities and are a key resource for industries such as transport and mining. Moreover, Arctic aquatic environments have global significance as sentinels of climate change, as sources of greenhouse gases and as critical components of cryospheric systems. The Arctic terrestrial environment is characterized by numerous lakes that dot the landscape and by the predominance of snow and ice in the form of glaciers, ice caps, ice sheets and permafrost (permanently frozen ground).

**LACIERE**

Arctic glacier ice comprises mountain glaciers (i.e., ice bodies whose shape and size are controlled by bedrock topography), ice caps (i.e., dome-shaped ice bodies that entirely submerge the underlying rock) and the Greenland Ice Sheet (i.e., an ice sheet that originates over the Arctic Ocean (Vincent et al., 2008)). Four sites within LIA are important for lake systems of the Arctic to which they provide freshwater. Lakes are amongst the most productive aquatic ecosystems. Hence, it is suggested that nutrient supply strongly limits the annual production in Arctic aquatic ecosystems. However, the primary variable controlling daily primary production by phytoplankton during summer would be nutrient availability (Vincent et al., 2008). Nutrient delivery for biological production to planktonic communities in lakes and rivers is low in the Arctic. The release of nutrients from the catchments by soil microbes is limited due to low temperature, low moisture, and freezing. Nutrient recycling rates are also slowed with the low temperatures of water. Also, low temperature would likely slow the metabolism and growth of many of the organisms colonizing Arctic aquatic ecosystems. Hence, it is suggested that nutrient supply due to enhanced mining, and oil and gas activities, and anthropogenic introduction of invasive species via more transport in the North (Prowse and Reist, 2013).

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Nomination Last Ice Area

nutrient availability, root density and plant stability. It also provides a habitat for viable ancient microorganisms that live within permafrost. On the other hand, vegetation moderates ground surface temperature by insulating and protecting permafrost directly or indirectly by trapping snow. No species are dependent on permafrost and no ecosystems are limited by the presence of permafrost, as tundra can be underlain by permafrost. However, the presence of permafrost is playing a key role in plant species composition as it restricts the types of plants that can grow.

As a result of warming, the permafrost is degrading rapidly in many Arctic regions (IPCC, 2013). Temperatures in the permafrost have risen by up to 2 °C over the last three decades, although there are large regional variabilities (Callaghan et al., 2011a), and the southern limit of permafrost has moved northward in Russia and Canada (Callaghan et al., 2011a). The thawing trend is projected to continue and by 2100, the area currently underlain by permafrost near the surface (upper 3.5 m) would decrease by 37-81% (IPCC, 2013).

Permafrost thawing is having drastic impacts on the built and natural environments (Callaghan et al., 2011a). Arctic infrastructure (e.g. schools, hospitals, roads, airports) is greatly damaged and the design of any future development will need to take into account the instability of the permafrost. Also, permafrost thawing on mountain slopes can lead to rock slope instability and landslides. In addition, coastal erosion is enhanced since the Arctic coastline is composed of unconsolidated material, rich in ice. Permafrost thawing during summer, the coasts are especially sensitive to the action of waves and experience high annual erosion rate. Moreover, the outcomes of thawing permafrost are at the opposite for hydrology; landscape dryness is increasing in the boreal forest and ponds are drying, while waterlogging occurs in some flat areas of the Subarctic. As a result, permafrost degrades in a continuum from rising temperatures in frozen ground (which increases the unfrozen water content) and reduced load-bearing strength of the permafrost to complete thawing of ice-rich ground (which causes the surface to subside and creates depressions in the ground, termed ‘thermokarst’). Biodiversity and ecosystem processes on land and in aquatic ecosystems are being affected by these changes in hydrology. Finally, permafrost thawing is having a critical impact in greenhouse gases emissions. Recent research has demonstrated that permafrost soils (both terrestrial and beneath continental shelves) hold large pools of carbon; mostly in the form of methane (CH4) and nitrous oxide (N2O), and that the emission of these two powerful greenhouse gases from thawed permafrost could greatly increase radiative forcing and trigger abrupt climate change (Callaghan et al., 2011a).

TERRITORIAL BIODIVERSITY

This section examines Arctic terrestrial biodiversity. Soil microbial biodiversity, vegetation and animal biodiversity for terrestrial ecosystems (except aquatic ecosystems) are first described, then, aquatic biodiversity is presented.

All terrestrial biodiversity in the Arctic is driven by the low temperatures, increase in atmospheric CO2 concentration and a higher availability of nutrient will likely contribute to this. Increased in microorganisms activity implies accelerate soil organic matter decomposition (Koyama et al., 2013).

Vegetation

Environmental and climatic conditions are extreme for Arctic vegetation and control the plant communities that can grow. Summer temperature is the most important factor that influences Arctic vegetation (CAVM team, 2003). The mean July temperatures are near 0°C on the northernmost Arctic Islands. At these low temperatures, plants are at their metabolic limits, and small differences in the total amount of summer warmth make large differences in the amount of energy available for maintenance, growth, and reproduction. Higher summer temperatures cause the size, horizontal cover, abundance, productivity, and variety of plants to increase. Environmental factors such as landscape, topography, soil chemistry, soil moisture, and the history of plant colonisation also influence the distribution of plant communities in the Arctic (CAVM Team, 2003). Most plants found in the Arctic are dwarf shrubs, herbs, lichens and mosses that grow close to the ground, and they cover the land surface that is not ice-covered (5.05 million km2 are covered in ice). However, vegetation out of 7.11 million km2 of total land surface (Walker et al., 2005). With decreasing latitude (moving from the High Arctic to the Low Arctic), the amount of ice-covered and vegetation growth increases significantly, allowing the size, abundance, and variety of plants to increase as well (CAVM team, 2003).

The circumpolar Arctic is subdivided along latitudinal subzones (Figure 44) and longitudinal floristic provinces (Figure 44). The latitudinal north-south axis reflects the present climate and vegetation gradient divided into five different subzones, A, B and C delineate bioclimatic subzones of the High Arctic, while D and E are located in the...
Low Arctic (Table 4). Very steep bioclimate gradients occur in mountains and these areas are therefore mapped as elevation belts (CAVM team, 2003). There is a clear increase in species numbers from the northernmost High Arctic subzone A (102 species) to the southernmost Low Arctic subzone E (2180 species) (Daniëls et al., 2013). The longitudinal east-west axis reflects different conditions in the past such as glaciations, land bridges and north-south trending mountain ranges (particularly in Asia). These influences have limited the exchange of species between parts of the Arctic (Daniëls et al., 2013).

Table 4. Vegetation properties in each bioclimate subzone from CAVM Team (2003). Note that the subzone A is also known as polar desert, subzone B as Arctic tundra, subzones C and D as typical tundra and, subzone E as southern tundra. Alternatively, subzone A can also be named the Arctic herb subzone (absence of sedges and woody plants); B, the northern Arctic dwarf shrub subzone; C, the middle Arctic dwarf shrub subzone; D, the southern Arctic dwarf shrub subzone; and E, the Arctic shrub subzone.

<table>
<thead>
<tr>
<th>Subzone</th>
<th>Mean July Temp (°C)</th>
<th>Summer warmth index</th>
<th>Vertical structure of plant cover*</th>
<th>Dominant vegetation (taxonomic description &amp; proportion)</th>
<th>Total plant species (100 stemmed species)</th>
<th>Nudger vascular plant species in local flora</th>
</tr>
</thead>
</table>
| A       | 0.3                | <6                  | %5 cover of vascular plants
40% cover of mosses and lichens
by meadow and alpine
vegetation
B. gla. ssp. gla. and
B. gla. ssp. megalophylla | B1, G1
<3 <0.3 <90 |
| B       | 3.5                | 6-9                 | 50-60% cover of vascular plants,
up to 80% cover of mosses and
lichens by meadow and
alpine vegetation
B. gla. ssp. gla. and
B. gla. ssp. megalophylla | B1, G1
P1
<5 <0.2 <100 |
| C       | 5-7                | 9-12                | 50% cover of vascular plants,
up to 65% cover of
mosses and lichens
by meadow and
alpine vegetation
B. gla. ssp. gla. and
B. gla. ssp. megalophylla | G2, P1
<0.5 <1.5 <70 |
| D       | 7-9                | 12-20               | 50% cover of vascular plants,
up to 60% cover of
mosses and lichens
by meadow and
alpine vegetation
B. gla. ssp. gla. and
B. gla. ssp. megalophylla | G1, S1
<0.5 <0.5 <120 |
| E       | 9-12               | 20-35               | 50% cover of vascular plants,
up to 80% cover of
mosses and lichens
by meadow and
alpine vegetation
B. gla. ssp. gla. and
B. gla. ssp. megalophylla | G4, S1, S2
<0.5 <0.5 <200 |

*Based on the CAVM Team (2003). **Based on the CAVM Team (2003).

Although species number could increase in the course of future studies. The estimated species number of Arctic bryophytes is 1000 species, significantly less than 1.750 lichen species and 2,218 vascular plants (Daniëls et al., 2013). High Arctic sites have fewer species of bryophyte than Low Arctic areas (Daniëls et al., 2013). Also, almost 80% of these species have a circumpolar distribution (Daniëls et al., 2013). Vascular plants contribute to vegetation biomass in stable, wet-to-moist sites, and they add to species richness of many vegetation types in the Arctic (Daniëls et al., 2013). Single shoots occur almost everywhere, and particularly in the High Arctic (Daniëls et al., 2013). Vascular plant endemism is well developed in the Arctic as 5% of the Arctic vascular plant species are endemic to the Arctic (Daniëls et al., 2013). Interestingly, the relative percentage of vascular plant species endemic to the Arctic decreases from the High Arctic to the Low Arctic (Daniëls et al., 2013). In contrast, Arctic endemism is not strongly pronounced for bryophytes (Daniëls et al., 2013). No species in the Arctic is currently considered as invasive, although some are at risk of becoming so with increasing human traffic combined with climate change (Daniëls et al., 2013).

Plants have always played a central role in the lives and cultures of Arctic indigenous peoples (Daniëls et al., 2013). Vascular plants are consumed and used for medicines. The use of bryophytes is little known and therefore, probably very restricted.

Vegetation in the LIA

The LIA region encompasses three bioclimate subzones. Islands between the Peary Channel and the M’Clure Strait, at the northwestern margin of the Canadian Arctic Archipelago, are characterized by subzone A, the northern coast of Ellesmere Island and Greenland, and territories on each shore of the Peary Channel, by subzone B, and the interior of Ellesmere Island and Devon Island, by subzone C. Two floristic provinces are found within LIA. Northern Greenland, Ellesmere Island, Axel Heiberg Island and Devon Island are part of the Ellesmere – North Greenland province. The other is...
Terrestrial fauna of the LIA

The terrestrial fauna of the Last Ice Area (LIA) consists of various species that are adapted to the cold and harsh environments. The terrestrial mammal species reported for LIA are listed at Appendix I. The terrestrial predator community of the LIA consists of Arctic wolf (Canis lupus arctos), Arctic fox (Vulpes lagopus), red fox (Vulpes vulpes, on Devon Island) and stoat (Mustela erminea). Aerial predators in the LIA include rough-legged hawk (Buteo lagopus), gyrfalcon (Falco rusticolus), peregrine falcon (Falco peregrinus), snowy owl (Bubo scandiacus), jaegers and skuas (Stercorariidae), gulls (Laridae) and raven (Corvus). There are many species of shorebirds that prey on invertebrates and molluscs on land, shorelines and tidal mud flats. Polar bears are summer season terrestrial predators and scavengers in the seasonal sea ice regions.

Caribou

Rangifer tarandus is called caribou in North America and reindeer in Europe. It is a conspicuous Arctic terrestrial species with a circumpolar distribution in the tundra and taiga zones of northern Europe, Siberia and North America (Figure 48). They have supported many cultures for thousands of years through meat and fat, and skins for clothing. Caribou is found throughout the LIA; the subspecies Peary caribou (Rangifer tarandus pearyi) is found on the islands of the Canadian Arctic Archipelago and coastal northwestern Greenland (Government of Canada, 2013b; Jensen and Christensen, 2003). This subspecies is small (males measure 1.7 m in length on average), have relatively short legs, they are almost completely white and they have small antlers. Peary caribou migrate seasonally between islands to maximize their use of the available habitat. During summer, they feed on dense vegetation in the slopes of river valleys and upland plains, while during winter they occur in areas where the snow is shallow. Caribou is an important prey species for many Arctic carnivores such as wolves and polar bears. The caribou is listed under the category of ‘least concern’ of the IUCN red List due to a wide circumpolar distribution and presumed large populations (Henttonen and Tikhonov, 2008).

The number of mature individuals of Peary caribou in the population of the Queen Elizabeth Islands is 2100 (Government of Canada, 2013b), the Inglefield/Pruhoe Land population and the Olrik Fiord population in Greenland had an estimated population size of 2,300 in 1999, and an unknown number, respectively (Greenland Institute of Natural Resources, 2013). The best current estimate of the total Peary Caribou population, including calves, is 7890 (Government of Canada, 2013b). The Peary caribou population is declining; the total population has declined by 72% since 1980, and the population on the Queen Elizabeth Islands has declined by about 37% (Government of Canada, 2013b). The Peary caribou has been assessed as endangered under both the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Species At Risk Act (SARA) (Government of Canada, 2013b). The main threat to this caribou population would be winters with heavy and persistent snow accumulation, in association with freezing rain and warm periods that cause the formation of ice crusts over vegetation. For this reason, climate change could lead to the disappearance of this population (Government of Canada, 2013b).

Industrial development is still absent in the Queen Elizabeth Islands and northwestern Greenland. However, future industrial operations could hamper seasonal migrations and cause disruptions during critical periods of their life cycle (Government of Canada, 2013b). Certain Peary caribou herds are characterized by low number and low genetic diversity, which reduce their ability to adapt to environmental stresses (Government of Canada, 2013b).

Lemming

The northern Collared (or Arctic) lemming (Dicrostonyx groenlandicus) is an important species in the High Arctic ecosystem and it is widely distributed throughout the LIA. It cope with the severe winters by positioning its nest and tunnels under the snow. The Arctic lemming feeds on wil-
Low and grasses while it is the most important prey species for Arctic fox, stoat and snowy owls. Skuas, jaegers, and Christensen, 2003). The white Arctic foxes feed on lemmings and show much greater population fluctuations than the blue Arctic foxes that feed on stable food sources (Jensen and Christensen, 2003).

Musk ox
Musk ox (Ovibos moschatus) have lived in the Arctic for many thousands of years and are survivors of the last ice age. They live in the Arctic tundra in Canada, Alaska, and Greenland (throughout LIA). These animals are well adapted to the Arctic climate with their long thick, shaggy fur that keeps them warm. Additional adaptations to the harsh Arctic climate are short legs and large, rounded hooves that allow them to move easily through shallow snow. These large mammals (up to 360 kg) feed on roots, mosses and lichens and they supplement their diet with Arctic flowers and grasses during summer. Musk ox live in herds of two to three dozen animals and they use cooperation to deal with predation by wolves and dogs. When they are threatened, they form a circle, protecting their young in the middle, and they show their sharp horns outward. They are an integral part of the Inuit lifestyle as they provide large quantities of meat, and warm versatile insulating fur.

Aquatic biodiversity
Aquatic biodiversity is known to decrease with increasing latitude, likely reflecting the increasingly harsh conditions (Prowse and Reist, 2013). Also, Arctic aquatic environments often have a simplified food web structure compared to temperate latitudes (Vincent et al., 2008). They range from simple with flagellates, ciliates and rotifers at the highest trophic level, to more complex with well-developed zooplankton and fish communities (Vincent et al., 2008). Shallow lakes and ponds exhibit extreme seasonal variations in temperature, water levels and light conditions, which influence the abundance of Arctic lakes as they represent the highest trophic level in the Arctic food web in lakes without fish. Their abundance is therefore limited by water supply and their ability to survive in cold conditions (Rautio et al., 2008). Rotifers, copepods, cladocerans, fairy shrimps (Anostraca) and mysids are the main components of the zooplanktonic community of Arctic lakes and ponds (Rautio et al., 2008). The distribution of zooplankton species in Arctic lakes is largely dependent on geographic location and correlates with the distance from locations that escaped glaciation in the Pleistocene period (Rautio et al., 2008). Zooplankton feed preferably on phytoplankton but they can also feed on benthic microbial mats in shallow lakes (Rautio et al., 2008). Some species live on the edge of their environmental tolerance while others have adapted to life at low temperatures, short growing season, long periods of ice cover, and low food supply (Rautio et al., 2008). In lakes with fish, predation controls the zooplankton community, as fish are size-selective in their feeding. Zooplankton therefore tends to be small and transparent in order to escape predation in these lakes (O’Brien et al., 2004; Rautio et al., 2008). Different species of fish have different impacts on the zooplanktonic community (O’Brien et al., 2004).

Arctic lakes display low fish abundance and diversity. Within the Arctic, eastern Canadian Arctic and Greenland are the regions with the lowest diversity because they were deglaciated last during the last ice age and that they still retain large ice sheets (Christiansen and Reist, 2013). Five fish families (capers and minnows, trout and salmonids, sculpins, perches and lami preys), out of the 17-19 present, comprise most of the Arctic freshwater diversity (Christiansen and Reist, 2013). Some lami preys, and some trout and salmonids are anadromous, meaning that they undertake regular migrations between marine waters, and among freshwaters.
to benefit from the productive marine coastal environments for feeding, and freshwater for reproduction, juvenile growth and over-wintering. These species are especially important for subsistence fisheries by local communities. About 127 species of fish occur in freshwater Arctic and sub-Arctic environments, which represent around 1% of the global fish estimate on the planet (Christiansen and Reist, 2013). Nonetheless, this estimate certainly underestimates Arctic freshwater fish diversity, as it does not consider the important diversity that occurs below the species level. Out of these 127 species, 83-85 are obligate freshwater forms, 39 are anadromous and 2 species are catadromous (fishes which migrate from freshwater into the sea to spawn) (Christiansen and Reist, 2013). Arctic char (*Salvelinus alpinus*) is the freshwater fish the most northeery distributed as it is the only species to occur north of 75°N latitude, and in the LIA (Christiansen and Reist, 2013). Lake A, a coastal lake located at 83°N on the northern coast of Ellesmere Island contains an anadromous Arctic char population (Veillette et al., 2012). This fish species is widely distributed throughout many habitats and exhibit different life-history strategies that vary with latitude, resulting in high adaptability (Power et al., 2008). Some populations are resident in lakes and they show complex variety of life-history tactics: they vary in growth and feeding patterns, and occupy distinct niches. Other populations are anadromous. Lake char (*Salvelinus namaycush*) is also present in many lakes in the south of the Canadian Arctic Archipelago (Power et al., 2008).

The well-developed benthic microbial mats at the bottom of Arctic Lakes, streams and ponds are dominated by cyanobacteria, but other algal groups such as chlorophytes and chromophytes are also present (Jungblut et al., 2009). The benthic invertebrate community is abundant in Arctic lakes and is mostly composed of insect larvae (chironomids), oligochaete worms, snails, mites and turbellarians (Rautio et al., 2008). The only macrophytes present in Arctic Lakes are benthic mosses (Jungblut et al., 2009).
2b. History and development

History of geological development
There is no history of geological development within the proposed area. There is the potential for a lead-zinc development to the east of the proposed boundary in the Greenland portion at a property known as Citronen Fiord. There are no current or proposed geological developments in the immediate vicinity of the proposed area.

History of land use
The most northerly districts of both Nunavut and Western Greenland have historically been sporadically occupied, with a few permanent communities currently settled in the region. Dorset (300 BC) and Thule archeological evidence points to use of the northern areas of both Nunavut and western Greenland. It is presumed that camps found throughout the Arctic are remnants of early Inuit harvesting activity centred around whales while they were plentiful. When whales were no longer plentiful, Inuit changed their harvesting activities to make use of other more abundant species, such as seals, which led to a more nomadic existence (Riewe, 1975).

Pre-Dorset people inhabited Ellesmere Island as early as 2000 B.C.E. Over time the Thule people replaced the pre-Dorset. Remnants of Thule villages can still be found in many of the inlets and fiords of Ellesmere Island. Thule were no longer occupying the area by the 18th century, although hunting parties from Greenland and Arctic Bay sometimes visited Ellesmere Island (Riewe, 1975).

The settlement of Grise Fiord is located on the north shore of Jones Sound on the southern tip of Ellesmere Island, the most mountainous island in the Arctic Archipelago. The terrain is harsh and the surrounding mountains provide limited support for wildlife. The sea is frozen 10 months of the year with break-up occurring in mid-August. From May to August the sun never sets, while the dark season lasts from October to mid-February (Riewe, 1975).

In western Greenland, the communities of Qaanaq (formally a town), Sisimiut, Mariusq, Qeqertat, and Siorapaluk comprise Qaatsuitsup municipality (all formally settlements) and are the northermost communities. Qaatsuitsup Kommunia (municipality) covers all land and communities from the Ilulissat area (http://www.qaatsuitsup.gl/en/om-kommunen/Cities-and-settlements). In Nunavut, Grise Fiord and Resolute are the northermost communities established by the Government of Canada to assert sovereignty over the High Arctic in the 1960's. Inuit refer to Grise Fiord as "the place that never thaws" (Aujjuittuq) (Hamlet of Grise Fiord, 2012) and Resolute (also referred to as Resolute Bay) is known as "place with no dawn" (Qaasuittuq) (Unknown, 2012).

Inuit from Grise Fiord hunt caribou and polar bears on the East Coast of Ellesmere Island. Qaanaq, Siorapaluk and Qeqertat residents are active hunters in Northwest Greenland.

Additional stressors
Although the Arctic is still sparsely populated, it is experiencing pressure from numerous sources. Climate change is a prominent driver affecting the entire Arctic. The climatic impacts for marine and terrestrial environments, and their related biodiversity, have been addressed throughout the different sections of this report. Additional important factors that threaten the integrity of Arctic ecosystems are enhanced mining and oil and gas activities, increased shipping, and contaminants by local pollution or long-range transport. These anthropogenic stressors are also likely to interplay and have cumulative effects. A companion report by WWF on the non-renewable resources of the LIA looks more closely at the economic probability of exploitation of these resources.

Oil and gas development in the Canadian Arctic began in the Beaufort Sea in the 1970's. Wells were drilled from artificial islands. Seismic exploration was also realized in the Lancaster Sound region of the Canadian Arctic Archipelago during the 1970's (Niemi et al., 2010). At the moment, the highest known oil and gas potentials of the Canadian Arctic Archipelago are in the Sverdrupt Basin and Lancaster Sound (Figure 53).

The Canadian portion of LIA does not hold any major mineral project at the moment (Aboriginal Affairs and Northern Development Canada, 2012b). However, the Po-
Laris zinc mine was an underground zinc mine located on Little Cornwallis Island. This mine closed in 2002 following over 20 years of production. On nearby Baffin Island, the Nanisivik Mine was a zinc-lead mine located in the community of Nanisivik. This mine was opened in 1976 and closed in 2002 due to low metal prices and declining resources. The Mary River Property is a proposed iron ore mine located on Baffin Island. It is one of the largest and richest undeveloped iron ore projects in the world and involves the construction, operation, closure and reclamation of an open pit mine. Mineral activities in Greenland have grown rapidly in the past 10 years and this trend would continue in the future (Tejsner and Frost, 2012). Exploration licences for minerals in the Greenlandic portion of the LIA are located in northwest Greenland and northeast Greenland (Figure 54) and companies target iron, gold, lead, zinc, copper and rare earth elements.

Recent conservation history
There are several protected areas in LIA and its vicinity, which cover terrestrial and marine environments (Figure 56). Moreover, Canada is currently in the process of establishing a national marine protected area near Lancaster Sound (Parks Canada, 2013a). Lancaster Sound is the eastern entrance to the Northwest Passage, the sea route through Canada’s Arctic Archipelago. This area is crucial for marine mammals including seals, narwhals, belugas, bowhead whales, walrus and polar bears. Lancaster Sound is also bordered by huge seabird breeding colonies, with populations in the hundreds of thousands. In addition, Qausuittuq is a proposed national park that includes most of Bathurst Island and a number of islands west of Bathurst Island, and is north of the Polar Bear Pass National Wildlife area (Parks Canada, 2012). This area has been chosen to represent the Western High Arctic Natural Region. This park would help to protect the endangered Peary caribou and other wildlife. The following paragraphs briefly describe each of the protected areas located in the LIA.

North-East Greenland National Park
The North-East Greenland National Park is the largest (with an area of 972,000 km²) and most northerly national park in the world. It extends three nautical miles into the adjacent sea. The Greenland Government established it in 1992, 15 years after it was appointed a UNESCO biosphere reserve. Mineral exploration is possible within this park (Tejsner and Frost, 2012). It is the only national park in Greenland and it encompasses the entire northeastern coastline of 18,000 km, and interior sections of Greenland. The Sirius dog Sledge Patrol, Danish Navy, monitors the coastline of the park and is stationed at Daneborg, located in the National Park. Also, the research station Zackenberg is located within the park. There are no permanent Inuit settlements within the park.

Quttinirpaaq National Park
Quttinirpaaq (“top of the world” in Inuktitut) National Park is located on the northeastern part of Ellesmere Island, only 720 km from the North Pole. It is the northernmost park in Canada and the second largest, after Wood Buffalo National Park. It covers 37,775 km², of which 2,670 km² are marine (Wood, 2007). It was established as Ellesmere Island National Park Reserve in 1988, and the name was changed to Quttinirpaaq in 1999, when Nunavut was created, and became a national park in 2000 (Parks Canada, 2013b). Quttinirpaaq is pending an application as a UNESCO world heritage site (UNESCO, 2013). Most of Quttinirpaaq National Park is classified as an Arctic desert. The park consists of sedimentary mountains, ice caps, glaciers, ice shelves and fiords. The park borders on the Arctic Ocean and rises to Mount Barbeau (a nunatak), at 2,616 m, the highest mountain in eastern North America. Much of the

Figure 55. Two long-tailed ducks sit together on sea ice.
© Clive Tesar / WWF
Figure 57. Muskox on tundra, Ellesmere Island.

Figure 58. Arctic hare. Kane Basin. © Vichi Sartarsten / WWF
3.1. Brief synthesis
LIA property with a total area of 12,928,522.23 ha is located on the northern coast of Ellefson Island (the Canadian Arctic Archipelago) and Greenland. It includes the Quttinirpaaq National Park (Canada), and the northern part of Greenland National Park (Denmark).

LIA property is a unique example of present-day glaciers, from heavy domes to thick outlet tongues, and various glacial relief forms: winding U-shaped fjords having dissected the coastline, monumental through valleys and cliffy nunataks, concurrently being the highest North American mountains to the east of the Rocky Mountains. It is ornamented by prominent alpine-type ridges – traces of Greenland national Park (Denmark) and the northern part dissected the coastline, monumental through valleys and glaciated relief forms: winding U-shaped fjords having observed: from snow and firn to the ice ones. the activity of former large-scale glaciations. So far, LIA is a platform at the nominated property – a kind of “open-air glaciology adjacent waters are also unique. this is the only distribution Quttinirpaaq national Park (Canada), and the northern part of the LIA includes two marine ecoregions defined within the circumpolar Arctic (WWF, 2012): High Arctic Archipelago and North Greenland. Within these ecoregions, Ecologically and Biologically Significant Areas (EBSAs) were identified. These areas were selected based on their ecological importance to fish, birds and mammals, as these species are the most widely studied Arctic groups. The High Arctic Archipelago ecoregion multiyear pack ice is critical as it is the largest remaining island pack ice refugium in the world and it supports unique communities. This area is particularly important for under-ice communities, seabirds and polar bears. Ellefson Island includes three EBSAs: the Ellesmere Island ice shelves, the Nansen-Eureka-Greyf Fjord that supports unique fish communities and aggregations of polar bear and ringed seal and Princess Marie Bay that is used by several seal species, walrus and narwhal. The Arctic Basin pack ice is the EBSA that contains the thickest and oldest sea ice of the Arctic and is a unique habitat for under-ice and planktonic communities, and is a significant summer refuge for polar bear. The North Greenland ecoregion contains Peary Land, an important area for marine mammals and seabirds. According to the data of deepwater drilling, the Greenland ice sheet has been continuously developed for the last 18 mln years, which makes LIA property even more valuable and unique as a source of information related to the Earth development during this period. LIA property will contribute for the diversity of environmental conditions in the region, especially, areas of present-day glacial processes development in the Arctic.

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3.1.b Criteria under which inscription is proposed (and justification for inscription under these criteria)

Criterion viii
LIA area is a unique natural region which present-day appearance has been largely influenced by glacial processes and the influence is still relevant. The glacial shell covering significant part of the area is being developed here under specific and harsh conditions of the Arctic desert. Within the region, picturesque ice domes and caps can be seen, with their width exceeding 900 m, and the age being more than a hundred thousand years. The ice and sheets of correlated glacial deposits concentrated along the seashore keep the memories of the Earth development history, being the source of valuable scientific data related to the climatic conditions during and after this long-outlasting period. Large outlet glaciers (e.g., Petermann Glacier dewatering the Greenland ice sheet, being 70 km in length and 15 km in width) are highly dynamic. They not only tend to shrink progressively due to the global warming, but are also characterized by such a phenomenon as pulsation. Due to instantaneous glacier calvings, numerous icebergs float in the ocean, age-diverse morainic ridges are formed, conditions for new ecosystems development – primary settlements in the territories that have been previously covered with a glacier shell – are produced. Only a short time ago, in the beginning of the 20th century, marine tidewater glaciers drifted along the northern coastline of the archipelago. Arctic Archipelago – the Ward Hunt glacier – a fragment of the monolithic ice shelf – is a unique example of a contemporary continental shelf glacier in the Arctic which is still breaking up with the tabular icebergs formation. The northern coast of the Canadian Arctic Archipelago and Greenland is the only region on Earth where the perennial sea ice cover remains stable for the whole summer. Ice packs cause damage to the recurring polynya, they are separated from ice shelves by tidal ice - ice – areas of high biodiversity and are key elements in the development of marine ecosystems. The glacial relief of LIA is also very diverse characterized by an unidirectional combination of deep trough valleys, coastlines heavily dissected by fjords and alpine-type ridges and masses. Peaks or nunataks protruding above the ice domes are the highest ones in the Canadian Arctic (Barbeau Peak, 2616 m) and form a typical impressive relief of steeply- roofed rocky residuals.

I-shaped glacial valleys that are now turned into sea inlets not only determine a specific coastline appearance, but are also of paramount importance for Island and marine ecosystems connections. Most part of the territory which at present is not covered by eternal ice due to extremely bad moisture conditions in the region has evident traces of more thick covers related to the Quaternary period.

Criterion ix
The property may provide valuable evidence on the impacts of climate change to large-scale natural Arctic ecosystems if proper monitoring and research take place. There is a rich variety of terrestrial and coastal/marine environments with complex and intricate mosaics of life at various successional stages from 500 m below sea level to 5000 m.

Due to the surface circulation of the Arctic Ocean, the ice that remains at the minimum sea ice extent is mostly located within and north of the LIA. Sea Ice plays several roles such as influencing local and global climates, affecting the albedo and ocean circulation and, determining atmospheric-ocean exchanges. This area is changing at one of the most rapid pace on the planet and there is a pressing need to learn more about its biodiversity before it vanishes.

Criterion x
The nominated area and nearby marine environments provide diverse habitats for a multitude of unique life forms highly adapted in their life history, ecology and physiology to the extreme and seasonal conditions of this environment. Arctic marine food webs involve numerous pathways, are relatively simple and vulnerable to perturbations. Since the LIA is predicted to hold the last remaining ice during summer, the area may be important for ice-obligate and ice-associated marine mammal species. Seven marine mammals live in the Arctic all year long and many others species occupy Arctic waters seasonally. The Arctic is an important region for seabird diversity and large breeding colonies are found on cliffs and islands. The nominated area is considered vulnerable, rare, and increasingly threatened (with shrinkage of their sea ice habitat or other climate-related impacts) species including polar bears, ice-associated whales and seals and Peary caribou. Species listed on the IUCN Red List are polar bear (vulnerable) and narwhal (near threatened).

Two thirds of the global polar bear population could disappear by 2050 if climate warming continues (Amstrup

Nomination Last Ice Area

et al., 2008). For the other third, the LIA is likely to be prime habitat. LIA is home to six polar bear subpopulations. The populations of the Archipelago and Baffin Bay are in decline, even if sea ice is still extensive in these regions. Within LIA, thick multiyear ice will be replaced by annual ice, which is associated with greater productivity, and may create more favourable habitats for polar bears over the short term, acting as potential refugia. LIA will remain the best habitat available for polar bears as this region will retain ice the longest.

Within LIA, thick multiyear ice will be replaced by annual ice, which is associated with greater productivity, and may create more favourable habitats for polar bears over the short term, acting as potential refugia. LIA will remain the best habitat available for polar bears as this region will retain ice the longest.

Some features of the sea ice environment are of particular ecological significance since they are highly productive: marginal ice zones, flaw leads and polynyas. The largest polynya in the LIA region is the North Water Polynya (NW) in northern Baffin Bay between Canada and Greenland. This polynya forms each spring and is the largest and most productive recurring polynya in the Arctic.

Some features of the sea ice environment are of particular ecological significance since they are highly productive: marginal ice zones, flaw leads and polynyas. The largest polynya in the LIA region is the North Water Polynya (NW) in northern Baffin Bay between Canada and Greenland. This polynya forms each spring and is the largest and most productive recurring polynya in the Arctic.

The Arctic contains numerous freshwater ecosystems of different types (glaciers, lakes, rivers, ponds, streams, wetlands). Within LIA, glaciers and ice caps are present on Devon and Ellesmere islands, and at the periphery of Greenland. The Greenland Ice Sheet spreads up to the northern part of Greenland. The microbial water column diversity of some Arctic lakes was reported to be very rich despite their extreme locations. Lake Hazen is one of the largest freshwater lakes in the circumpolar region, and has attracted great scientific interest as a thermal oasis in a polar desert.

Integrity substantiation has been in accordance with the "Operational Guidelines for the Implementation of the World Heritage Convention":

Paragraph 88: (a) The nominated property is a whole nature complex with its main components inseparably tied with each other by the common origin, history and the dynamics of natural development, and includes all elements necessary to express its Outstanding Universal Value.

(b) By its size (129,285.2 km²) the nominated property is enough to support the functioning of nature complexes of the Last Ice Area and to ensure the complete representation of the features and processes which convey its significance.

(c) Climate change is a prominent driver affecting the entire Arctic. Additional important factors that threaten the integrity of Arctic ecosystems are enhanced mining and oil and gas activities, increased shipping, and contaminants by local pollution or long-range transport. These anthropogenic stressors are also likely to interplay and have cumulative effects.

These additional stressors are currently minimal in the nominated area ecosystems. There is currently no hydrocarbon development and any major mineral project in the nominated sector of the LIA. The complex of specially protected areas is not subject to economic impact. Bearing the status of the National Park – the highest nature conservation status in Canada and Denmark – the whole nominated territory (with the exception of part of the Robeson Channel) provides protection and the following natural development of representative complex of ecosystems. The territory is extremely hard to access, which gives it supplementary guarantees of integrity and safety.

Paragraph 90: The biophysical processes and landform features of the nominated area are intact.

Paragraph 93: The nominated property contains all of the key interrelated and interdependent elements of Arctic ecosystems in their natural relationships. The northern coast of the Canadian Arctic Archipelago and Greenland is the only region on Earth where the perennial sea ice cover remains stable for the whole summer. The glacial relief of the nominated sector of the LIA is very diverse characterized by an unirrelated combination of deep trough valleys, coastlines heavily dissected by fjords and alpine-type ridges and massifs. Peaks protruding above the ice domes form a typical relief of steeple-roofed rocky residuals.

Paragraph 94: Due to its sheer size, the nominated property contains all necessary elements to demonstrate the key aspects of processes that are essential for the long term conservation in northern Baffin Bay between Canada and Greenland. This polynya forms each spring and is the largest and most productive recurring polynya in the Arctic.

The Arctic contains numerous freshwater ecosystems of different types (glaciers, lakes, rivers, ponds, streams, wetlands). Within LIA, glaciers and ice caps are present on Devon and Ellesmere islands, and at the periphery of Greenland. The Greenland Ice Sheet spreads up to the northern part of Greenland. The microbial water column diversity of some Arctic lakes was reported to be very rich despite their extreme locations. Lake Hazen is one of the largest freshwater lakes in the circumpolar region, and has attracted great scientific interest as a thermal oasis in a polar desert.
3.2 Comparative Analysis

**LAST ICE AREA (LIA)** IN THE GLOBAL BIOGEOGRAPHICAL CONTEXT

Global analysis of distribution of the World Heritage Sites shows that among all the biogeographic realms distinguished according to the well-known M. Udvardy’s scheme of biogeographical regions (1975) relatively few UNESCO sites are located in the Neartic region. This area is vast and includes the USA, Canada, Greenland, and northern Mexico (see Fig. 60). Most natural heritage sites are concentrated in western USA and Canada. Meanwhile, the entire northeastern Neartic region is the area with an obvious lack of World Heritage Sites, while being a vast territory comparable to the entire Western Europe in terms of its area. The same conclusion can be drawn if one deals with this problem in the context of individual biomes (i.e., at the lower taxonomic level): the addition of this site, in the northeastern Canadian Arctic Archipelago and northern Greenland, to the world map of UNESCO sites is extremely topical. Indeed, an analysis of the sites that have already been inscribed on the World Heritage List shows that the following 5 biomes, or habitat types, are the most common ones in it: wetlands, many endemic, rare and disappearing flora and fauna species.

The nominated sector of the LIA is a very illustrative site that demonstrates the classical marine Arctic ecosystem with the typical “trophic pyramid” consisting of all the main links (marine mammals, fish, aquatic invertebrates, zoo- and phytoplankton, microorganisms, as well as seals and polar bear, the largest land predator found in the Arctic that is the top of this pyramid).

**3.1. Protection and management requirements**

Nowadays the status of the National Park (which meets the requirements of the II IUCN category) ensure the conservation and development of the unique ecosystem complex. Any economical or business activities are prohibited on the territory of the SPAs and restricted within their buffer zones. Such activities as hunting, mining operations, commercial building and transport routes construction are prohibited. Thus, territorial and functional integrity is achieved within such a vast territory of the natural complexes.

Eastern part of the nominated property, the North-East Greenland National Park, in 2007 was appointed a UNESCO Biosphere Reserve.

The special protected areas within the nominated territory possess enough financial and administrative resources for long-term conservation of the property’s Outstanding Universal Value. The Sirius Dog Sledge Patrol, Danish Navy, monitors the coastline of the North-East Greenland National Park and is stationed at Danco, located in the National Park. Also, the research station Zackenberg is located within the park.

Figure 60. Terrestrial biomes, terrestrial and freshwater biogeographic realms, and marine biogeographic realms.

Integrated coordination system of transboundary property management is being developed at the moment. WWF scientists are in discussion with Inuit and governments located in the LIA region in order to plan the future management of this area to ensure the resilience of all life forms dependent on sea ice. A recommendation of the Arctic Biodiversity Assessment (CAFF, 2013a) goes in that sense and states the importance of developing and implementing mechanisms to conserve Arctic biodiversity under the deteriorating trend of sea ice, glaciers and permafrost.

Thus, from this viewpoint, awarding the world heritage status to the site under study (Last Ice Area) is extremely relevant, since it would make the distribution of the UNESCO sites more uniform. This fact would fully comply with the policy of the World Heritage Center and the Global Strategy that has been being fulfilled since 1994 to make the World Heritage List more well-balanced and adequate so that it fully displays the natural and cultural diversity of the world and comprises all the main geographical zones of the Earth.

**LIA AND OTHER ARCTIC AND SUBARCTIC NATURAL WORLD HERITAGE NOMINATIONS**

Today, only a few Natural World Heritage Sites are located in the Arctic and Subarctic region. Wrangel Island being the northernmost of them (N 71). Hence, it was reasonable to add the northern portion of the temperate zone, together with the Natural World Heritage Sites lying in this zone, to a comparative analysis. In this case, the number of possible analogues is eight (Table 5). The analogues are compared below in terms of the key parameters related to criteria vii, vi and ix (Tables 6, 7 and 8).

The Southern Hemisphere also contains three Natural World Heritage Sites located in the circumpolar zone: “The New Zealand Subantarctic Islands”, Australia’s Macquarie Island and the Heard Island and McDonald Islands. However, the circumpolar zone in the Southern Hemisphere is known to differ drastically from that in the Northern Hemisphere, so it is rather difficult to draw an analogy in this case.

A comparison of the nominated property with other natural sites that have already been inscribed on the UNESCO World Heritage List reveals a number of unique features. This fact gives grounds for claiming that this region of the Arctic has global value in the context of three criteria highlighted by the UNESCO Convention, namely: criterion 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”; criterion ix – “to
Table 5. World Heritage Sites located in the Arctic, the Subarctic, and the northern portion of the temperate zone.

<table>
<thead>
<tr>
<th>Name of the World Heritage Site</th>
<th>Country/Country or States</th>
<th>Criteria and year of inscription</th>
<th>Area</th>
<th>Brief description</th>
<th>Geographic co-ordinates</th>
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<tr>
<td>LIA (i)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Palouse Plateau</td>
<td>Canada/USA</td>
<td>(vii) (ix)</td>
<td>1 867 251 ha</td>
<td>The Subaestic.</td>
<td>n 46° 24' 8&quot; E 117° 10' 11&quot;</td>
</tr>
<tr>
<td>Putorana Plateau</td>
<td>Russia/U.S.A.</td>
<td>(vii)</td>
<td>3 280 150 ha</td>
<td>The western foothills of the Northern Ural with coniferous taiga, high-mountain zone with alpine relief.</td>
<td>n 66° 15' 57&quot; E 102° 49' 22&quot;</td>
</tr>
<tr>
<td>Wrangel Island</td>
<td>Russia/Canada</td>
<td>(i) (iv) (vii) (viii)</td>
<td>1 310 300 ha</td>
<td>The Arctic. The large mountainous island with the highest peak; fastness covered with tundra forest and rock fields.</td>
<td>n 68° 17' 24&quot; E 153° 40' 59&quot;</td>
</tr>
<tr>
<td>Ilulissat Icefjord</td>
<td>Denmark</td>
<td>(vii) (viii)</td>
<td>3 280 000 ha</td>
<td>The icy fjord in southwestern Greenland.</td>
<td>n 64° 26' 40&quot; W 50° 53' 20&quot;</td>
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<td>Proofed criteria:</td>
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<td>Environmental conservation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>– “to preserve outstanding values from the point of view of science or conservation.”</td>
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<tr>
<td>Wildlife conservation:</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>– “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.”</td>
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<tr>
<td>Ecological processes:</td>
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<td></td>
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<tr>
<td>– “to be outstanding examples representing significant geographic or physiographic features of the relief.”</td>
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<td></td>
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</tr>
<tr>
<td>Values of the site:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Putorana Plateau</td>
<td>Russia/U.S.A.</td>
<td>(vii)</td>
<td>3 280 000 ha</td>
<td>The western foothills of the Northern Ural with coniferous taiga, high-mountain zone with alpine relief.</td>
<td>n 66° 15' 57&quot; E 102° 49' 22&quot;</td>
</tr>
<tr>
<td>Wrangel Island</td>
<td>Russia/Canada</td>
<td>(i) (iv) (vii) (viii)</td>
<td>1 310 300 ha</td>
<td>The Arctic. The large mountainous island with the highest peak; fastness covered with tundra forest and rock fields.</td>
<td>n 68° 17' 24&quot; E 153° 40' 59&quot;</td>
</tr>
<tr>
<td>Ilulissat Icefjord</td>
<td>Denmark</td>
<td>(vii) (viii)</td>
<td>3 280 000 ha</td>
<td>The icy fjord in southwestern Greenland.</td>
<td>n 64° 26' 40&quot; W 50° 53' 20&quot;</td>
</tr>
</tbody>
</table>
Nomination Last Ice Area

Table 6. World Heritage Sites in the Arctic, Subarctic, and the northern portion of the temperate zone: diversity of ecosystems and forms of natural processes.

<table>
<thead>
<tr>
<th>Name of the World Heritage Site</th>
<th>Glacier types (continental, maritime, mountain, outlet, icebergs)</th>
<th>Glacial forms of the relief (trough valleys, cirque landforms, moraines, outwash plains, etc.)</th>
<th>Glaciological processes (exaration, calving glaciers, formation of icebergs, icebergs in glacial mounser)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIA</td>
<td>+ Ice caps, flat-summit glaciers, outlet glaciers, icebergs, pack ice</td>
<td>+ trough valleys, cirque landforms, fjords</td>
<td>+ Exaration, calving glaciers, formation of icebergs, icebergs in glacial mounser</td>
</tr>
<tr>
<td>Ilulissat Icefjord</td>
<td>+ outlet glacier</td>
<td>+ Fjord, trough valley</td>
<td>+ Rapidly moving glacier, calving glaciers, icebergs</td>
</tr>
<tr>
<td>Surtsey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laponian Area</td>
<td>+ Mountain-valley glaciers</td>
<td>+ Outwash plains, U-shaped valleys, cirque landforms, moraines, moraine terraces, corries, drumlins, erratic blocks</td>
<td>+ Rapidly moving glaciers, exaration</td>
</tr>
<tr>
<td>Virgin Komi Forests</td>
<td>+ small corrie and niche glaciers</td>
<td>+ Trough valleys, cirque landforms, corries, mountain terraces, moraines</td>
<td>+ Exaration</td>
</tr>
<tr>
<td>Putorana Plateau</td>
<td>+ small corrie and niche glaciers</td>
<td>+ Trough valleys, corries, fjords</td>
<td>+ Exaration</td>
</tr>
<tr>
<td>Wrangel Island</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Klause / Wrangel-St. Elias / Glacier Bay / Tatshenshini-Alsek</td>
<td>+ Ice-field, outlet glaciers, Philippine glaciers</td>
<td>+ Trough valleys, fjords, moraines, hanging valleys</td>
<td>+ Exaration, calving glaciers, formation of icebergs, icebergs in glacial mounser, moraine deposits</td>
</tr>
<tr>
<td>Nabanek</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Mountain glaciation (ice caps at the Roosevelt Range.) This is the ice-free land area located farthest to the north which is qualified as a polar desert due to very low precipitation. If you look at Table 6, you can see that only few properties can partially compare to the LIA area, including the Ilulissat Icefjord, Laponian Area, Virgin Komi Forests, Putorana Plateau, Klause / Wrangel-St. Elias / Glacier Bay / Tatshenshini-Alsek. These areas have considerable contemporary glaciation or abundant traces of past glacial periods. Ilulissat Icefjord can be considered a partial analogue to the LIA area as it is one of the few outlet glaciers connecting the Greenland ice sheet with the sea. Other similarities with the nominated area include a receiving fjord where icebergs are actively formed and its location at the border of the Arctic and Subarctic. Nevertheless, the Ilulissat Icefjord is a very limited area, which does not provide such a variety of types and forms of glacial relief as the LIA area enormously exceeds it in size. Therefore, they cannot be considered similar in every way. The Laponian Area is a region with strong alpine type relief, abundance of corries, trough valleys, kuru valleys and contemporary mountain-valley glaciers with a rich zone of accumulative glacial relief (outwash plains, moraines.) However, this area is located further south, in the northern portion of the temperate zone, therefore, there are no elements of transection or semi-continental glaciation (ice caps, flat-summit glaciers), which are so characteristic and unique of the LIA area, there are no fjords connected to the coast or outlet glaciers either. The main volume of glaciation here took place much earlier, during the periods of wider mountain and continental glaciation, whereas the LIA area is the scene of the widespread recent glacial activity. The Virgin Komi Forests and Putorana Plateau bear the traces of powerful glacial processes, but at the moment only small residual corrie and niche glaciers are observed here. In the first case, exaration processes are concentrated in the most elevated axial zone of the Ural mountain range (the area of Mount Narodnaya, Telposiz mass) where large corries with morainic lakes, alpine type ranges and karstings, tunnel valleys are prevailing. In the second case, glaciers had a significant impact on the entire mass, as a result of which numerous valleys dissecting it have a trough-like outlook, and their mouths filled with large lakes resemble typical fjord coasts. Partially, this relief of the Putorana Plateau corresponds to the features of the Hazen Plateau affected by glaciers in the southern part of the Quittiniapaq National Park on Ellesmere Island, with its 600-meter high cliffs and a dense network of troughs. However, the location of both properties, the Komi Forests and Putorana Plateau, in the northern portion of the temperate zone and Subarctic, respectively, implies almost complete lack of recent glacial activity, therefore, they cannot be considered similar to the LIA area.

The Klause / Wrangel-St. Elias / Glacier Bay / Tatshenshini-Alsek are the areas where heavy glaciation is combined with alpine relief. The world’s largest ice field outside the Arctic Circle is situated here. Remarkable tectonic activity in the area provides for the active interaction of glaciers with the relief. The high dynamics of their sizes and depths results in the formation of large trough valleys and hanging valleys connected to them, which are the traces of more powerful glaciation. Due to the increased hydration, one of the longest outlet glaciers in the world is formed here, and the largest continuously active glacier is preserved here as well. And still, these two so different areas of glacial activity cannot be compared due to all their peculiar features. It is the development in the conditions of increased hydration and high tectonic activity which results in overly intense glaciation in the uncharacteristic area (in the Subarctic to temperate zones). On the contrary, adverse dry weather conditions of the LIA area allow us to trace the typical formation of

Table 7. World Heritage Sites in the Arctic, Subarctic, and the northern portion of the temperate zone: diversity of ecosystems and forms of natural processes.

<table>
<thead>
<tr>
<th>Name of the World Heritage Site</th>
<th>Terrestrial ecosystems</th>
<th>Coastal ecosystems</th>
<th>Insular ecosystems</th>
<th>Marine ecosystems</th>
<th>Continental ice sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIA</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ilulissat Icefjord</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Surtsey</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Laponian Area</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Virgin Komi Forests</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Putorana Plateau</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Klause / Wrangel-St. Elias / Glacier Bay / Tatshenshini-Alsek</td>
<td>-</td>
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<td></td>
</tr>
<tr>
<td>Nabanek</td>
<td>-</td>
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</tr>
</tbody>
</table>
glaciers and slow transformation influenced by them of the relief into arctic deserts that are so widespread in the northern sector of the Nearctic and virtually not included not affected by the last glaciation at all (the mountainous nunataks that are also the highest peaks in North America, the relief forms in the nominated property which can be considered similar in every way to none of the sites already included in the World Heritage List. Only the areas of Kluane / Wrangel-St. Elias / Glacier Bay / Tatshenshini-Alsek and Ilulissat Icefjord can be considered partial analogues in terms of the contemporary glaciation scale, and the Laponian Area, Virgin Komi Forests, Putaran Plateau are partially similar to it as far as the scale of glaciation is concerned. However, nearly all of these areas are located in the northern part of the temperate zone or in the Subarctic, consequently, even existing glaciers are developing in the conditions absolutely different to those of the LIA area. The amount and variety of contemporary glaciation and glacial relief forms in the LIA are similar and even greater than those of the other regions it has been compared to. Therefore, it appears that the inscription of the LIA in the World Heritage List by criterion viii will significantly expand the diversity of its natural environment, in particular, the areas of contemporary development of glacial processes in the Arctic.

**CRITERION IX:** an outstanding example of current ecological and biological processes in evolution and development of terrestrial and fresh water ecosystems.

The combination of various Arctic ecosystems (Insular, coastal, and marine ones).

The statement "to be an outstanding example representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, coastal and marine ecosystems" is valid about the LIA property. Table 7 shows that among all the analogues that have already been recognized on the World Heritage List, the broadest range of Arctic ecosystems can be found within the nominated property. Thus, the terrestrial properties in the Subarctic and the northern portion of the temperate zone, the Laponian Area, Virgin Komi Forests, Putaran Plateau and Nahammi cannot compete with LIA for the diversity of ecosystems as they contain neither coastal nor marine ecosystems. Furthermore, these properties lie south of LIA (N 61–69), thus there is no ice cover. Although Surtsey and Kluane / Wrangel-St. Elias / Glacier Bay / Tatshen- shini-Alsek contain neither coastal, nor marine areas, they are located further south than the other areas shown in Table 6 cannot be compared with the LIA in terms of relief glaciation. They were either not affected by the last glaciation at all (the mountainous area due to its rather southern location), or they were formed in suitable conditions (the Subarctic), but fairly recently (the volcanic island of Surtsey was formed only half a century ago), therefore, they have not been under an active glaciation impact.

Thus, it is fair to say that the LIA is a unique "open-air museum of glaciology". Here, you can observe both spectacular glaciers of various types: large ice caps, small flat-summit glaciers, thick outlet glaciers, and diverse glacial relief forms: meandering deep fjords, which are numerous and the main links (marine mammals, fish, aquatic invertebrates, Figure 61. Arctic Fox. © Stefan Widstrand 2004).
nomination last ice area

In particular, it is true for the significant portion of the area can be compared to LIA in this respect: Ilulissat Icefjord and compared only to Wrangel Island (Russia), which is known to attention to the problem of its conservation. the total popu-

ecosystem is represented so completely and is characterized with the walrus, other pinnipeds also inhabit this area: the

bear, the largest land predator found in the Arctic ecosystem is represented so completely and is characterized however, the value of the site under consideration is

LIA region has a much more ancient ice sheet, which is older than

features in common (mostly due to the presence of islands and vast

for the LIA area and its complete absence even in the past on Wrangel Island because of the fact that both properties are separated by the North Atlantic, the North Pole is located at the opposite “poles” of the Arctic zone of the Earth; hence, they cannot be regarded as obvious analogues. In conclusion, we insist that the LIA region is not inferior to other Arctic and Subarctic World Heritage Sites that have already received the status of Natural World Heritage properties in terms of the main aspects related to criteria (cultural and natural diversity of species, the presence of globally endangered species). This fact is particularly important if one takes into account the high-latitude location of the area, harsh climate, and high degree of ice cover: one would not expect to have abundant flora and fauna under such extreme conditions.

thus, one of the key local species, the polar bear, is referred to as a "polar oasis", where the combination of local factors forms the ecosystem rich in Arctic marine species, which is rather typical and representative of the high latitude areas of the Western Hemisphere. This region is of the greatest significance for conservation of the polar bear, cetaceans, pinnipeds, and colonial seabirds.

Species, the presence of globally endangered species). This fact is particularly important if one takes into account the high-latitude location of the area, harsh climate, and high degree of ice cover: one would not expect to have abundant flora and fauna under such extreme conditions.

Summarizing the comparative analysis, we would like to mention that two UNESCO properties (Ilulissat Icefjord in northwestern Greenland and some areas of Wrangel Island in the Chukchi Sea) are the ones most similar to LIA with respect to Individual parameters. The largest bears are found in the LIA area and are similar in terms of their geographic proximity (they both belong to the same super-

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they are either continental (e.g., the Putorana Plateau), or border with sea or ocean coasts (e.g., Alaska site), or are individual islands (Surtsey Island). LIA cannot significantly contribute to conservation of endangered marine mammal species. Much younger is the fauna of the seabirds: approximately 40 seabird species inhabit the LIA area; many of them have been inscribed in the IUCN Red List of Endangered Species. In this aspect, LIA is one of the other Arctic and Subarctic marine World Heritage Sites where large con-

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Excerpts from the Operational Guidelines for the Implementation of the World Heritage Convention

I. INTRODUCTION

1.8 The World Heritage Convention

4. The cultural and natural heritage is among the priceless and irreplaceable assets, not only of each nation, but of humanity as a whole. The loss, through deterioration or disappearance, of any of these most prized assets constitutes an impoverishment of the heritage of all the peoples of the world. Parts of that heritage, because of their exceptional qualities, can be considered to be of “Outstanding Universal Value” and as such worthy of special protection against the dangers which increasingly threaten them.

5. To ensure, as far as possible, the proper identification, protection, conservation and presentation of the world’s heritage, the Member States of UNESCO adopted the World Heritage Convention in 1972. The Convention foresees the establishment of a «World Heritage Committee» and a «World Heritage Fund». Both the Committee and the Fund have been in operation since 1976.

6. Since the adoption of the Convention in 1972, the international community has embraced the concept of “sustainable development”. The protection and conservation of the natural and cultural heritage are a significant contribution to sustainable development.

7. The Convention aims at the identification, protection, conservation, presentation and transmission to future generations of cultural and natural heritage of Outstanding Universal Value.

8. The criteria and conditions for the inscription of properties on the World Heritage List have been developed to evaluate the Outstanding Universal Value of properties and to guide States Parties in the protection and management of World Heritage properties.

9. When a property inscribed on the World Heritage List is threatened by serious and specific dangers, the Committee considers placing it on the List of World Heritage in Danger. When the Outstanding Universal Value of the property which justified its inscription on the World Heritage List is destroyed, the Committee considers deleting the property from the World Heritage List.

I.C The States Parties to the World Heritage Convention

12. States Parties to the Convention are encouraged to ensure the participation of a wide variety of stakeholders, including site managers, local and regional governments, local communities, non-governmental organizations (NGOs) and other interested parties and partners in the identification, nomination and protection of World Heritage properties.

13. States Parties to the Convention should provide the Secretariat with the names and addresses of the governmental organization(s) primarily responsible as national focal point(s) for the implementation of the Convention, so that copies of all official correspondence and documents can be sent by the Secretariat to these national focal points as appropriate. A list of these addresses is available at the following Web address:

http://whc.unesco.org/en/statespartiesfocalpoints

States Parties are encouraged to publicize this information nationally and ensure that it is up to date.

14. States Parties are encouraged to bring together their cultural and natural heritage experts at regular intervals to discuss the implementation of the Convention. States Parties may wish to involve representatives of the Advisory Bodies and other experts as appropriate.
States Parties are encouraged to attend sessions of the World Heritage Committee and its subsidiary bodies.

I. Partners in the protection of World Heritage

39. A partnership approach to nomination, management, and monitoring provides a significant contribution to the protection of World Heritage properties and the implementation of the Convention.

40. Partners in the protection and conservation of World Heritage can be those individuals and other bodies, especially local communities, governmental, non-governmental, and private organizations and owners who have an interest and involvement in the conservation and management of a World Heritage property.

II. THE WORLD HERITAGE LIST

II.A Definition of World Heritage

Outstanding Universal Value

49. Outstanding Universal Value means cultural and/or natural significance which is so exceptional as to transcend national and international boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole. The Committee defines the criteria for the inscription of properties on the World Heritage List.

50. States Parties are invited to submit nominations of properties suitable for inscription on the World Heritage List (referred to as a Tentative List).

51. At the time of inscription of a property on the World Heritage List, the Committee adopts a Statement of Outstanding Universal Value, which describes the property for the world community as a whole. The Committee also decides on the boundaries of the property.

52. The Convention is not intended to ensure the protection of all properties of great interest, importance or value, but only for a select list of the most outstanding of these from the point of view of science or conservation.

53. Nominations presented to the Committee shall demonstrate the full commitment of the State Party to preserve the heritage concerned, within its means. Such commitment shall take the form of appropriate policy, legal, scientific, technical, administrative and financial measures adopted and proposed to protect the property and its Outstanding Universal Value.

II.D Criteria for the assessment of Outstanding Universal Value

77. The Committee considers a property as having Outstanding Universal Value (see paragraphs 49-53) if the property meets one or more of the following criteria. Nominated properties shall:

I. represent a masterpiece of human creative genius;

II. exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;

III. bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared;

IV. be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history;

V. be an outstanding example of a cultural settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;

VI. be directly or tangibly associated with events or living traditions, with, or without, with, or with, artistic and literary works of outstanding universal significance.

VII. contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;

VIII. contain habitation sites of importance that are directly or tangibly associated with living cultural traditions that are irreplaceable;

IX. 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.

V. Be to be deemed of Outstanding Universal Value, a property must also meet the conditions of integrity and/or authenticity and must have an adequate protection and management system to ensure its safeguarding.

II.F Protection and management

96. Protection and management of World Heritage properties should ensure that the property enjoys Outstanding Universal Value, including the conditions of integrity and/or authenticity at the time of inscription, and is sustained or enhanced over time. A regular review of the general state of conservation of properties, and thus also their Outstanding Universal Value, shall be done within a framework of monitoring processes for World Heritage properties, as specified within the Operational Guidelines.

97. All properties inscribed on the World Heritage List must have adequate long-term protection and management, including regulatory, institutional and/or traditional protection and management to ensure their safeguarding. This protection should include adequately defined boundaries. Similarly States Parties should demonstrate adequate protection at the national, regional, municipal, and/or traditional level for the nominated property. They should appoint appropriate local or regional authorities or regional bodies to the nomination with a clear explanation of the way this protection operates to protect the property.

Legislative, regulatory and contractual measures for protection

98. Legislative and regulatory measures at national and local levels should assure the survival of the property and its protection against development and change that might negatively impact the Outstanding Universal Value, or the integrity and/or authenticity of the property. States Parties should also ensure the full and effective implementation of such measures.

Boundaries for effective protection

99. The delineation of boundaries is an essential requirement in the establishment of effective protection of nominated properties. Boundaries should be drawn to ensure the full expression of the Outstanding Universal Value and the integrity and/or authenticity of the property.
Effective management involves a cycle of short, medium and long-term actions to protect, conserve and present the properties in a manner that is consistent with the purposes of the World Heritage Convention. Planning and management is essential to guide the evolution of properties over time and to ensure maintenance of all aspects of their Outstanding Universal Value, support the wider protection of conservation and cultural heritage, and promote and encourage the active participation of the communities and stakeholders concerned with the property as necessary conditions to its sustainable protection.


d) the involvement of partners and stakeholders;

 Sustainable use

Effective management systems depend on the type, characteristics and needs of the nominated property and its cultural and natural context. Management systems may vary according to different national, regional or local planning and management mechanisms, both formal and informal. Impact assessments for proposed interventions are essential for all World Heritage properties.

Objective of Reactive Monitoring

When adopting the process of Reactive Monitoring, the Committee was particularly concerned that all possible measures should be taken immediately to protect the property from any damage that might be difficult to reverse, so that the Committee may advise the State Party to prepare a World Heritage Rescue Mission Plan and to carry out its implementation, under the World Heritage Committee’s guidance.

Conclusion by the World Heritage Committee

The Secretariat will invite the Advisory Bodies to forward comments on the information received.

The information received, together with the comments of the State Party and the Advisory Body, will be taken into consideration when the Committee is invited to update the status of each World Heritage site.

Decision by the World Heritage Committee

The World Heritage Committee invites the States Parties to provide the Secretariat with a comprehensive list of all the World Heritage sites that have been proposed as possible candidates for the list of World Heritage at Risk, which will be considered by the Committee during its next session.

Information received from States Parties and/ or other sources

The World Heritage Committee invites the States Parties to provide any information that may be relevant to the protection of the Outstanding Universal Value of the World Heritage properties. The Committee will consider these reports and may advise the States Parties to take action to prevent any potential threats to the properties.

Excerpts from the Operational Guidelines

100. For properties nominated under criteria (v) – (vii), boundaries should be drawn to include all those areas and attributes which are a direct tangible expression of the Outstanding Universal Value of the property, as well as those areas which in the light of future research possibilities offer potential to contribute to and enhance such understanding.

101. For properties nominated under criteria (v) – (vi), boundaries should reflect the spatial requirements of habitats, species, processes or phenomena that provide the basis for their inscription on the World Heritage List. The boundaries should include areas immediately adjacent to the area of Outstanding Universal Value in order to protect the property’s heritage values from direct effect of human encroachments and impacts of resource use outside of the nominated area.

102. The boundaries of the nominated property may coincide with one or more existing protected areas, such as national parks or nature reserves, biosphere reserves or protected historical districts. While such established areas for protection may have formal and informal management zones, only some of those zones may satisfy criteria for inscription.

Management systems

Each nominated property should have an appropriate management plan or other documented management system which must specify how the Outstanding Universal Value of a property should be preserved, preferably through participatory means.

The purpose of a management system is to ensure the effective protection of the nominated property for present and future generations.

110. An effective management system depends on the type, characteristics and needs of the nominated property and its cultural and natural context. Management systems may vary according to different national, regional or local planning and management mechanisms, both formal and informal. Impact assessments for proposed interventions are essential for all World Heritage properties.

111. In recognizing the diversity mentioned above, common elements of an effective management system could include:

a) a thorough shared understanding of the property by all concerned;

b) a cycle of planning, implementation, monitoring, evaluation and feedback;

c) the monitoring and assessment of the impacts of trends, changes and of proposed interventions;

d) the involvement of partners and stakeholders;

e) the allocation of necessary resources;

112. Effective management involves a cycle of short, medium and long-term actions to protect, conserve and present the properties in a manner that is consistent with the purposes of the World Heritage Convention. Planning and management is essential to guide the evolution of properties over time and to ensure maintenance of all aspects of their Outstanding Universal Value, support the wider protection of conservation and cultural heritage, and promote and encourage the active participation of the communities and stakeholders concerned with the property as necessary conditions to its sustainable protection.

113. Moreover, in the context of the implementation of the Convention, the World Heritage Committee has established a process of Reactive Monitoring (see Chapter IV) and a process of Periodic Reporting (see Chapter III). Reactive Monitoring is the reporting by the Secretariat, specific reports and impact studies each year on the progress of work undertaken for the preservation of properties inscribed on the World Heritage List. Decision by the World Heritage Committee

The World Heritage Committee invites the States Parties to provide the Secretariat with a comprehensive list of all the World Heritage sites that have been proposed as possible candidates for the list of World Heritage at Risk, which will be considered by the Committee during its next session.

Information received from States Parties and/ or other sources

The World Heritage Committee invites the States Parties to provide any information that may be relevant to the protection of the Outstanding Universal Value of the World Heritage properties. The Committee will consider these reports and may advise the States Parties to take action to prevent any potential threats to the properties.

Excerpts from the Operational Guidelines

119. World Heritage properties may support a variety of ongoing and proposed uses that are ecologically and culturally sustainable, and which may contribute to the quality of life of communities concerned. The State Party and its partners must ensure that such sustainable use or any other change does not impact adversely on the Outstanding Universal Value of the property. An integrated approach to management planning and management would not be appropriate. Legislations, policies and strategies affecting World Heritage properties should ensure the protection of the Outstanding Universal Value and the conservation of natural and cultural heritage, and promote and encourage the active participation of the communities and stakeholders concerned with the property as necessary conditions to its sustainable protection.

120. FOR PROCESSING THE STATE OF CONSERVATION OF WORLD HERITAGE PROPERTIES

121. Reactive Monitoring is the reporting by the Secretariat, other sectors of UNESCO and the Advisory Bodies to the Committee on the state of conservation of specific World Heritage properties that are under threat. To this end, the States Parties shall submit by 1 February to the Committee through the Secretariat, specific reports and impact studies each year on the progress of work undertaken for the preservation of properties inscribed on the World Heritage List.

122. The World Heritage Committee invites the States Parties to provide the Secretariat with a comprehensive list of all the World Heritage sites that have been proposed as possible candidates for the list of World Heritage at Risk, which will be considered by the Committee during its next session.

Information received from States Parties and/ or other sources

The World Heritage Committee invites the States Parties to provide any information that may be relevant to the protection of the Outstanding Universal Value of the World Heritage properties. The Committee will consider these reports and may advise the States Parties to take action to prevent any potential threats to the properties.
ty within a reasonable period of time. The Committee may also decide that technical co-operation be provided under the World Heritage Fund for work connected with the restoration of the property, proposing to the State Party to request such assistance, if it has not already been done;

211. when the requirements and criteria set out in paragraph 177-182 are met, the Committee may decide to inscribe the property on the List of World Heritage in Danger according to the procedures set out in paragraphs 177-182;

212. when there is evidence that the property has deteriorated to the point where it has irretrievably lost those characteristics which determined its inscription on the List, the Committee may decide to delete the property from the List. Before any such action is taken, the Secretariat shall inform the State Party concerned. Any comments which the State Party may make will be brought to the attention of the Committee;

213. when there is evidence that the property has deteriorated to the point where it has irretrievably lost those characteristics which determined its inscription on the List, the Committee may adopt a Global Training Strategy for World Cultural and Natural Heritage. The primary goal of the Global Training Strategy is to ensure that necessary skills are developed by a wide range of actors for better implementation of the Convention. In order to avoid overlap and effectively implement the Strategy, the Committee will ensure links to other initiatives such as the Global Strategy for a Representative, Balanced and Credible World Heritage List and Periodic Reporting. The Committee will annually review relevant training issues, assess training needs, review annual reports on training initiatives, and make recommendations for future training initiatives.

National training strategies and regional cooperation

214. States Parties are encouraged to ensure that their professionals and specialists at all levels are adequately trained. To this end, States Parties are encouraged to develop national training strategies and include regional co-operation for training as part of their strategies.

Research

215. The Committee develops and coordinates international co-operation in the area of research needed for the effective implementation of the Convention. States Parties are also encouraged to make resources available to undertake research, since knowledge and understanding are fundamental to the identification, management, and monitoring of World Heritage properties.

International Assistance

216. Training and Research Assistance may be requested by States Parties from the World Heritage Fund (see Chapter VII).

Awareness-raising and education

217. States Parties are encouraged to raise awareness of the need to preserve World Heritage. In particular, they should ensure that World Heritage status is adequately marked and promoted on-site.

218. The Secretariat provides assistance to States Parties in developing activities aimed at raising public awareness of the Convention and informing the public of the dangers threatening World Heritage. The Secretariat advises States Parties regarding the preparation and implementation of on-site promotional activities and programmes, and may provide International Assistance. The Advisory Bodies and appropriate State agencies may also be solicited to provide advice on such projects.

Education

219. The World Heritage Committee encourages and supports the development of educational activities, materials and programmes.

International Assistance

220. States Parties are encouraged to develop educational activities associated with World Heritage with, wherever possible, the participation of schools, universities, museums and other local and national educational authorities.

221. The Secretariat may, in co-operation with the UNESCO Education Sector and other partners, produce and publish a World Heritage Educational Resource Kit, “World Heritage in Young Hands,” for use in secondary schools around the world. The Kit is adaptable for use at other educational levels.

222. International Assistance may be requested by States Parties from the World Heritage Fund for the purpose of developing and implementing awareness-raising and educational activities or programmes (see Chapter VII).

VII. THE WORLD HERITAGE FUND AND INTERNATIONAL ASSISTANCE

VII.A The World Heritage Fund

223. The World Heritage Fund is a trust fund, established by the Convention in conformity with the provisions of the Financial Regulations of UNESCO. The resources of the Fund consist of compulsory and voluntary contributions made by States Parties to the Convention, and any other resources authorized by the Fund’s regulations.

224. The financial regulations of the Fund are set out in document WHC/7 available at the following Web address: http://whc.unesco.org/en/privatefunds

VII.B Mobilization of other technical and financial resources and partnerships in support of the World Heritage Convention

225. To the extent possible, the World Heritage Fund should be used to mobilize additional funds for International Assistance from other sources.

226. The Committee decided that contributions offered to the World Heritage Fund for specific projects and other UNESCO projects for any property inscribed on the World Heritage List shall be accepted and used as international assistance pursuant to Section V of the Convention, and in conformity with the modalities established for carrying out the campaign or project.

227. States Parties are invited to provide support to the Convention in addition to obligatory contributions paid to the World Heritage Fund. This voluntary support can be provided through additional contributions to the World Heritage Fund or direct financial and technical contributions to properties.

228. States Parties are encouraged to participate in international fund-raising campaigns launched by UNESCO and aimed at protecting World Heritage.

229. States Parties are encouraged to promote the establishment of national, public and private foundations or associations aimed at raising funds to support World Heritage conservation efforts.

230. The Secretariat provides support in mobilizing financial and technical resources for World Heritage conservation. To this end, the Secretariat develops partnerships with public and private institutions in conformity with the Decisions and the Guidelines issued by the World Heritage Committee and UNESCO regulations.

231. The Secretariat should refer to the “Directives concerning UNESCO’s co-operation with private extra-budgetary funding sources” and “Guidelines for mobilizing private funds and criteria for selecting potential partners” to govern external fund-raising in favour of the World Heritage Fund. These documents are available at the following Web address: http://whc.unesco.org/en/privatefunds
Excerpts from the World Heritage Information Kit

**Success Stories**

The World Heritage Convention is not just *words on paper* but is above all a useful instrument for concrete action in preserving threatened sites and endangered species. By recognizing the outstanding universal value of a site, States Parties commit to its preservation and strive to find solutions for its protection. If a site is inscribed on the List of World Heritage in Danger, the World Heritage Committee can take immediate action to address the situation and this has led to many successful restorations. The World Heritage Convention is also a very powerful tool to rally international attention and actions through international safeguarding campaigns.

**FINDING SOLUTIONS**

Often, the World Heritage Committee and the States Parties, with the assistance of UNESCO experts and other partners, find solutions before a given situation deteriorates to an extent that would damage the site.

- Eliza Pyramids in Egypt: These pyramids were threatened in 1995 by a highway project near Cairo which would have seriously damaged the values of this archaeological site. Negotiations with the Egyptian Government resulted in a number of alternative solutions which replaced the disputed project.

- Royal Chitwan National Park in Nepal: This Park provides refuge for about 400 greater one-horned rhinoceros characteristic of South Asia. The World Heritage Committee, in the early 1990s, questioned the findings of the environmental impact assessment of the proposed Rapti River Diversion Project. The Asian Development Bank and the Government of Nepal revised the assessment and found that the river diversion project would threaten riparian habitats critical to the rhino inside Royal Chitwan. The project was thus abandoned and this World Heritage site was saved for the benefit of future generations.

- Archaeological Site of Delphi in Greece: At the time of its nomination in 1987, plans were underway to build an aluminium plant nearby the site. The Greek Government was invited to find another location for the plant, which it did, and Delphi took its rightful place on the World Heritage List.

- Whale Sanctuary of El Vizcaino in Mexico: In 1999, the World Heritage community campaigned against a plan for enlarging an existing salt factory to commercial scale in Laguna San Ignacio in El Vizcaino Bay, the last pristine reproduction lagoon for the Pacific gray whale. The World Heritage Committee forewarned the Mexican Government of the threats posed to the marine and terrestrial ecosystems, the gray whales as key species as well as the overall integrity of this World Heritage site by locating saltworks inside the Sanctuary. As a result, the Mexican Government refused permission for the saltworks in March 2000.

- Mount Kenya National Park/Natural Forest in Kenya: The nomination of this site was first referred back to the State Party on the basis of findings during the evaluation that suggested there were serious threats to the site, primarily illegal logging and marijuana cultivation inside the Park. The State Party responded with an action plan which included provision of additional vehicles, increased patrols, community awareness projects, training of forest guards and a review of the policy affecting the adjacent forest reserve. Based on these assurances, the Committee inscribed the site in 1997. Today, some threats still remain but there has been significant progress in the management of the site.

**INTERNATIONAL SAFEGUARDING CAMPAIGNS**

Sites for which international campaigns were launched in the 1960s, often became World Heritage sites, and the World Heritage concept itself developed from these first international campaigns launched by UNESCO.

Typically, however, international campaigns are much broader in their scope, more complex in their technology, and involve mil-
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Over the past forty years of inscribing natural and cultural properties on the prestigious World Heritage List and promoting their conservation and preservation for future generations, the World Heritage Convention has become an international success. With over 1000 properties inscribed on the UNESCO World Heritage List, neither UNESCO nor governments can protect World Heritage alone. The World Heritage Fund is by no means sufficient to ensure the preservation and promotion of our world’s natural and cultural treasures. As World Heritage is our shared heritage, the responsibility to protect it also needs to be shared between the States Parties, the international community and the civil society. With the number of World Heritage sites growing every year along with the number of threats facing them, the success of the Convention depends on this international solidarity but also on strengthened cooperation through partnerships.

The World Heritage Pact (Partnerships for Conservation) Initiative, launched in 2002, is a solutions-oriented approach to sustainable World Heritage conservation which aims to raise awareness and to mobilize sustainable resources for the long-term conservation of World Heritage. It involves a network of foundations, conservation and research institutions, companies and media organizations interested in assisting in the implementation of the World Heritage Convention.

In parallel to these partnerships, Pact is also expanding the existing network of bilateral and multilateral partnerships with governments and intergovernmental institutions to build and maintain a system of international cooperation. One of the major partners of the World Heritage Centre is the United Nations Foundation which has supported numerous biodiversity projects relative to World Heritage sites recognized for their outstanding natural values. Their important financial contribution has tripled the World Heritage Centre’s resources for the effective management and protection of natural World Heritage sites. Other agreements involving the provision of staff and the mainstreaming of World Heritage into development programmes have also been made with the World Bank, the Inter-American Development Bank, the United Nations Development Programme/Global Environment Facility (UNDP-GEF) Small Grants Programme, the Agence Francaise de Développement, the European Union and the Japan Bank for International Cooperation to ensure the conservation of World Heritage properties at local and national levels.

Recognizing that partnerships should be joint undertakings between partners in pursuit of common goals, the World Heritage Pact operates around key principles such as common purpose, transparency, bestow- ing no unfair advantages upon any partner, mutual benefit, respect and accountability. UNESCO’s policy framework for partnerships derives from the Global Compact guidelines adopted by the United Nations in 2000, whose ten universal principles provide a framework for businesses to integrate social values into the production of commercial goods and services.

By working with the World Heritage Centre, partners can share their expertise and management skills and gain a competitive advantage by integrating heritage protection into strategic planning. In turn, partners will receive public recognition for sharing UNESCO’s values and high standards for business in areas of human rights, work conditions and the environment. Furthermore, partners will have the opportunity to identify their business with an outstanding cause – working towards the sustainable preservation of our Planet’s diversity and the sustainable development of communities.

EXAMPLES OF PARTNERSHIPS FOR CONSERVATION:

In 2004, the World Heritage Centre entered into an ambitious ten-year capacity-building project to protect the biodiversity of India’s natural World Heritage sites, Manas Wildlife Sanctuary and Kaziranga, Keoladeo and Nanda Devi National Parks, including their endangered species: the one-horned rhinoceros, tiger, pygmy hog, Indian rhinoceros and elephant. The United Nations Foundation, United Nations Fund for

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lions of US dollars. The Abu Simbel project in Egypt, for example, cost in excess of US$40 million.

Over the years, 26 international safeguarding campaigns were organized, costing altogether close to US$1 billion.

Venice in Italy: This longest running international safeguarding campaign started in 1966 when UNESCO decided to launch a campaign to save the city after the disastrous floods of 1966, a task requiring time, a high degree of technical skill and, above all, money. The international sympathy that arose from this project was an important source of inspiration to the founding efforts of the Convention.

Temple of Borobudur in Indonesia: An international safeguarding campaign was launched by UNESCO in 1972 to restore this famous Buddhist temple, dating from the 8th and 9th centuries. Abandoned in the year 1000, the temple was gradually overgrown with vegetation and was not rediscovered until the 19th century. With the active participation of the Japan Trust Fund for the Preservation of World Cultural Heritage and other partners, the restoration of Borobudur was completed in 1983.

Partnerships for Conservation

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International Partnerships (UNFIP), American India Foundation, Ford and Suri Sehgal Foundation, Ashoka Trust for Research in Ecology and the Environment, and the Wildlife Institute of India are active partners in this initiative.

The Centre has also been working with the Congolese Institute for Nature Conservation, the Government of Belgium and the United Nations Foundation to safeguard the five World Heritage sites in the war-torn Democratic Republic of the Congo – Virunga, Garamba, Kahuzi-Biega and Salonga National Parks and Okapi Wildlife Reserve – to prevent the biological wealth of this rich region from disappearing. A monitoring programme using satellites to observe forest degradation has also been developed with the European Space Agency and the Belgian Ministry of Science.

UNESCO and its long standing media partner EVERGREEN Digital Contents, Japan, have launched a new partnership through a project aiming to promote World Heritage Education in Japan. The project focuses on raising the awareness of elementary school students about natural World Heritage sites and issues concerning them. As part of this partnership, a new i-mode site was developed for NTT DoCoMo called UNESCO kids. This entertaining and educational i-mode site, accessible by using all web compatible mobile phones, was designed to stimulate children into learning and caring for the environment in which they live. The project also aims to encourage them to visit World Heritage sites responsibly and share their experience by photographing their visits to contribute them to the i-mode site. This is the first i-mode site to provide information regarding World Heritage via a mobile phone service and it is anticipated that similar activities will spread throughout the world.

Training World Heritage site managers is one of the most valuable environments in heritage conservation, particularly as these sites confront the challenges of increasing flows of tourism and diminishing flows of international assistance for conservation and management. In January 2006, the World Heritage Centre joined forces – with the French NGO Association Vocations Patrimoine and its partners, the multinational groups AXA and MAZARS, to launch a programme of Fellowships for World Heritage site managers as well as people intending to pursue a career in World Heritage site management. A special focus of the programme is on training emerging leaders from developing countries or those working at sites with critical conservation needs. The fellowships provide tuition and living stipends for study at advanced level interdisciplinary training in World Heritage studies.
The Natural Heritage Protection Fund was established in 2000 in compliance with article 17 of the UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage. The Fund’s priority is the overall support of World Heritage properties, as well as obtaining this status for new natural sites both in Russia and the CIS. http://www.nhpfund.org

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LAST ICE AREA
Potential Transnational World Heritage Property (CANADA and DENMARK)