Polar Research

PERSPECTIVE

Managing visitor sites in Svalbard: from a precautionary approach towards knowledge-based management

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Keywords
Arctic; resource management; planning; tourism.

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Abstract

Increased tourism in the Arctic calls for more knowledge to meet management challenges. This paper reviews existing knowledge of the effects of human use on vegetation, fauna and cultural heritage in Svalbard, and it addresses the need for site-specific knowledge for improved management. This paper draws upon scientific studies, knowledge held by management authorities and local people, the Governor's database on visitors and visited sites and our own data from landing sites we visited. There is a certain level of basic knowledge available, allowing us to roughly grade the vulnerability of sites. However, there is a thorough lack of site-specific data related to the management of single locations or groups of similar locations. Future research needs to address specific on-site challenges in the management of visitor sites. Relevant management models and measures are discussed. We contend that a shift away from a blanket application of the precautionary principle and towards a more integrated, site-specific and evidence-based management plan will contribute to more trusted and reliable, and thereby acceptable among stakeholders, decisions in the management of growing tourism activity in Svalbard.

Many management policies are not evidence-based. Sutherland et al. (2004) found that conservation practitioners often (77% of cases) based management decisions on anecdotal information ("common sense", personal experience and speaking to other managers), and they called for more evidence-based management. The lack of knowledge-based management can be caused by an absence of data or by barriers to utilizing existing data—for example, decision-makers' access to the existing data may be restricted, or the data may have limited relevance for a particular management issue.

When managers lack data, the default policy is to use the precautionary principle, a widely accepted general principle in environmental management. This approach provides for action to avoid environmental damage in advance of scientific certainty of damage, and can result in regulating or forbidding human activities "just in case" (Cooney 2004). The precautionary principle is central to Norway's management of its biodiversity and protected areas, including the Svalbard Environmental Protection Act (which passed into law in 2001 and went into effect in 2002).

When several societal interests are present, as is usually the case, there is a risk that strict management precautions that override stakeholder interests or local input may escalate conflicts, frustrate stakeholders and undermine the trust and legitimacy of management decisions (Stern 2008). Scientific knowledge, rationality and democratic decision-making processes are strongly associated in our society. There is a need for transparency and evidence to achieve accepted and reliable management decisions (Geelmuyden 1993).

Increased tourism in the Arctic, including Svalbard, calls for more knowledge to meet management challenges. The United Nations Environmental Program's report on tourism in the polar regions highlighted potential problems for the Arctic environment and local societies connected to the growth in tourism (2007).

Citation: *Polar Research* 2012, *31*, 18432, http://dx.doi.org/10.3402/polar.v31i0.18432

The authors of the report pointed out that some of the criticism against tourism was not based on evidence, illustrating a need for more knowledge. The Auditor General of Norway (2006–07) has requested a new overall plan for Svalbard, with special focus on environmental protection, local population growth and increased traffic. In a recent white paper about Svalbard, the Ministry of Justice and the Police (2008–09) stated that new tools need to be developed to regulate and manage Svalbard's increased traffic and that recording and monitoring are necessary.

Some proposed strategies for managing tourist visitor sites in Svalbard have generated conflict. One proposed management action—based on a documented increase in visitors and landing sites, not on documented effects on vegetation, fauna or cultural heritage at individual sites—would reduce public landing access along the east coast of the archipelago. These areas were designated as nature reserves in 1973 to preserve large expanses of the Arctic as pristine natural reference sites for scientific research. Local residents and tourist operators strongly oppose the proposal of restricted landings, and different management institutions and levels have diverging opinions (Aarskog 2008).

This paper aims to: (1) review the status of existing knowledge and identify knowledge gaps and barriers for a future knowledge-based management of visitor sites; (2) address the need for including existing and new site-specific knowledge to improve resource and visitor management; (3) formulate a framework for a management strategy that is capable of assessing the level of vulnerability of individual visitor sites.

We reviewed existing knowledge of the effects on fauna, vegetation and cultural heritage with focus on relevant Arctic scientific studies, including the relatively few studies from Svalbard. We relied on existing databases to assess relevant environmental data for Svalbard, including Artskart (http://artskart.artsdatabanken.no/), Svalbardkartet (www.npolar.no/svalbardkartet) and Environmental Monitoring of Svalbard and Jan Mayen (MOSJ; http://mosj.npolar.no/). We drew on data from Svalbard Tourism, which systematically gathers sailing schedules, landing sites and tourist numbers from tour operators. We were granted access to the database of the Governor of Svalbard: since 1998, all individual visitors travelling outside the primary visitor area (Management Area 10; Kaltenborn & Emmelin 1993) must register and report their travel route to the Governor's office (Governor of Svalbard 2008). We limited our focus to include only the summer tourists visiting landing sites by boat.

In summer seasons from 2008 to 2010 we visited about 35 landing sites in the western and northern parts of Svalbard to collect data pertaining to site vulnerability to damage as a result of tourist traffic. The sites represented diverse use, natural and cultural heritage conditions and geographic positions. We also interviewed tourist operators, management authorities and scientists.

Reviewing existing knowledge related to management procedures, traditional and present human use and older biological studies was challenging since such information is found in internal reports and notes or has not been written up at all. To the extent we were able to access such information, we reviewed it for this study.

Legislation and management framework for tourism in Svalbard

The Svalbard Treaty (signed in 1920) established the archipelago as Norwegian territory, giving Norway sovereignty but also permitting all treaty parties (40 countries at present) to engage in economic activity here. This extraordinary legislation influences the political and economic goals for the archipelago and also has management implications, including Norway's obligation to protect Svalbard's natural environment. Norway's Svalbard policy aims to uphold the nation's sovereignty over the archipelago, protect its wilderness and cultural heritage sites and maintain Norwegian settlements (Ministry of Justice and the Police 2008–09). Management plans for Svalbard's economy list three core activities: coal mining, scientific research and tourism, with environmental protection having priority over natural resource extraction such that the archipelago can be seen as "one of the best managed wilderness areas in the world" (Overrein 2001; Ministry of Justice and the Police 2008–09).

The Svalbard Environmental Protection Act (accessible on the internet http://www.regjeringen.no/en/doc/Laws/Acts/Svalbard-Environmental-Protection-Act.html?id=173945) is a collection of environmental legislation addressing protected areas, species management for flora and fauna, cultural heritage, land-use planning, pollution, waste disposal, traffic and private cabins. The purpose of the act is to safeguard pristine areas in Svalbard while still providing for settlement, research and commercial activity (Governor of Svalbard 2010). Today 65% of Svalbard's land area and 87% of its territorial waters are protected by law, including seven national parks, six nature reserves, 15 bird sanctuaries and one geological protected area (Fig. 1). All traces of human activity originating prior to 1946, including a zone of 100 m in all directions, are also protected, and it is forbidden to disturb historical objects in any way. All traffic is forbidden in bird sanctuaries between 15 May and 15 August. Camping is prohibited in vegetated areas and in the safety zone around historical

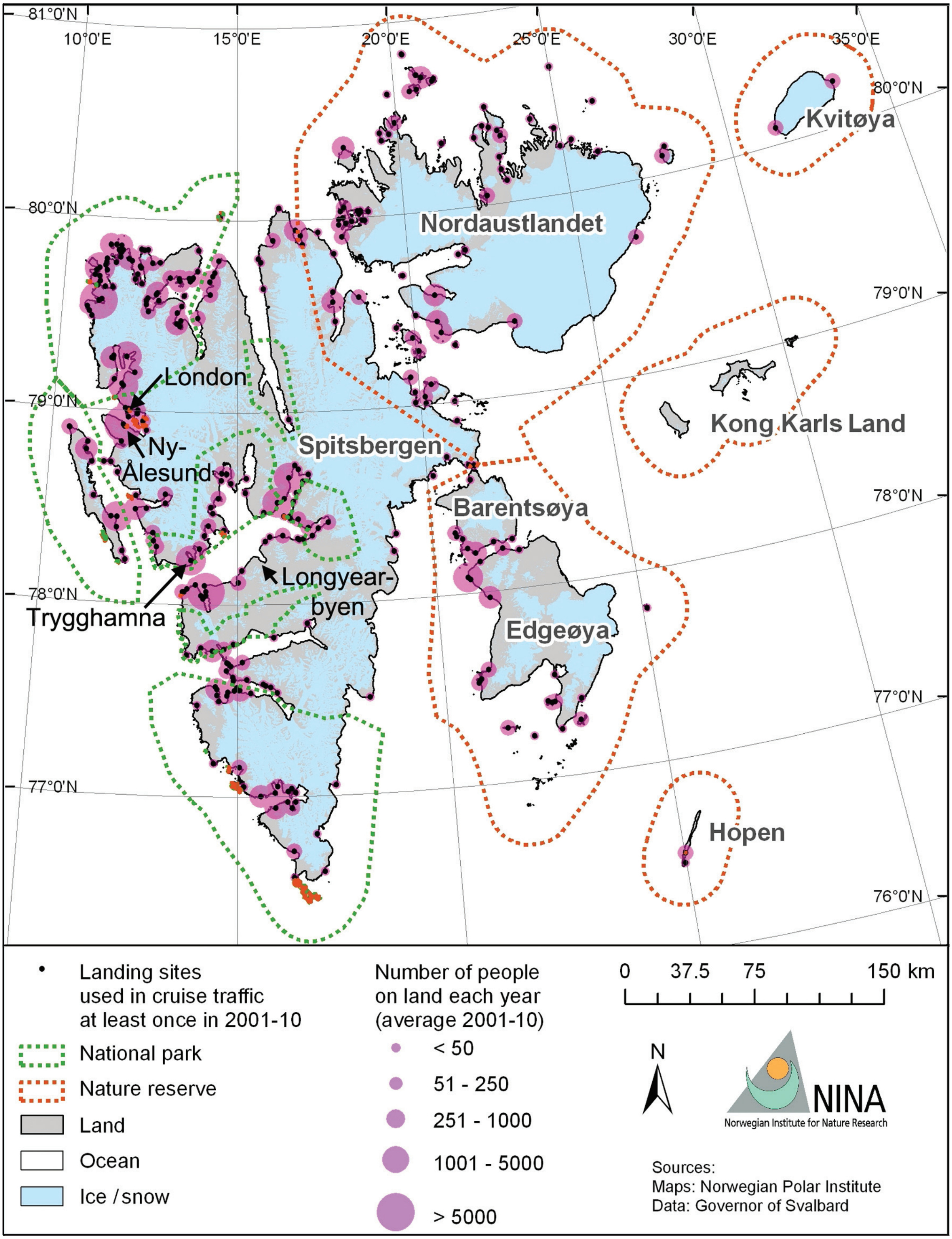

Fig. 1 The Svalbard Archipelago, including protected areas and place-names discussed in the text. Black dots represent the geographical distribution of landing sites used by coast cruise ships at least once between 2001 and 2010. Graded symbols show average numbers of visitors during the same time period.

remains. Tourists visiting Svalbard pay an environment fee to the Svalbard Environmental Protection Fund that supports initiatives that preserve Svalbard's unique wilderness and cultural heritage (Governor of Svalbard 2010).

The management plan for tourism and outdoor recreation approved by the Ministry of Environment (1995) uses a zoning system, adapted from the Recreational Opportunity Spectrum planning model (Kaltenborn & Emmelin 1993), with four categories: nature reserve, national park, recreation area and tourism area. The primary tourism area, called Management Area 10, encompasses central parts of Spitsbergen, including Isfjorden and the settlements of Longyearbyen and Ny-Ålesund. The 1995 plan was based on field studies concerning accessibility and regional suitability for different activities as well as surveys among different visitor groups and the local population. It was supposed to be updated every fourth year, and followed by a specific action plan. However, neither updates nor action plans have been implemented. The most recent tourism and outdoor recreation strategy statement explains that while regulation should not limit the number of visitors to Svalbard, regulations and restrictions should be used to address unacceptable tourist activities and behaviour and to protect vulnerable areas (Governor of Svalbard 2006). In its public documents (Svalbard Næringsutvikling 1997) and marketing materials (see http://www.spitsbergen travel.no/ and http://www.aeco.no/) the tourism industry itself also claims to have ambitious goals concerning its role in protecting Svalbard's wilderness.

Tourism impact and management models

Most tourists moving beyond the immediate vicinity of Longyearbyen travel by cruise ships. In 2009 cruise ships carried more than 100 000 visitors (60 000 if settlements are excluded; Norwegian Polar Institute 2011) and the number of people landing from cruise ships has more than doubled over the last 10 years (Fig. 2). The number of visited landing sites peaked in 2005, but seems to have stabilized at about 160 sites per year (Fig. 2). Landing sites are distributed throughout the archipelago, and the volume of traffic differs dramatically between sites (Fig. 1). We suspect that reporting of landing site visitors was inaccurate prior to 2001, so the increase in tourist landings may therefore not be as steep as Fig. 2 indicates (Overrein 2010). Moreover, it is not mandatory to report visits in Management Area 10, making it difficult assess geographical distribution of "traffic load" from the available statistics.

Social and ecological impacts at visited sites are not only determined by the total numbers of visitors but also by the type, timing and seasonality of the activities, as well as the spatial aspects of specific sites (Stankey et al. 1985; Cole 2004; Monz et al. 2010). In a review of recreation sites in protected areas, Monz et al. (2010) contend that the greatest impact on vegetation and soil comes when the visitor intensity is moderately low, and that impact flattens out with increasing visitor volume, provided visitors continue to use the same "spots and paths". Monz et al. (2010) also found that impact on

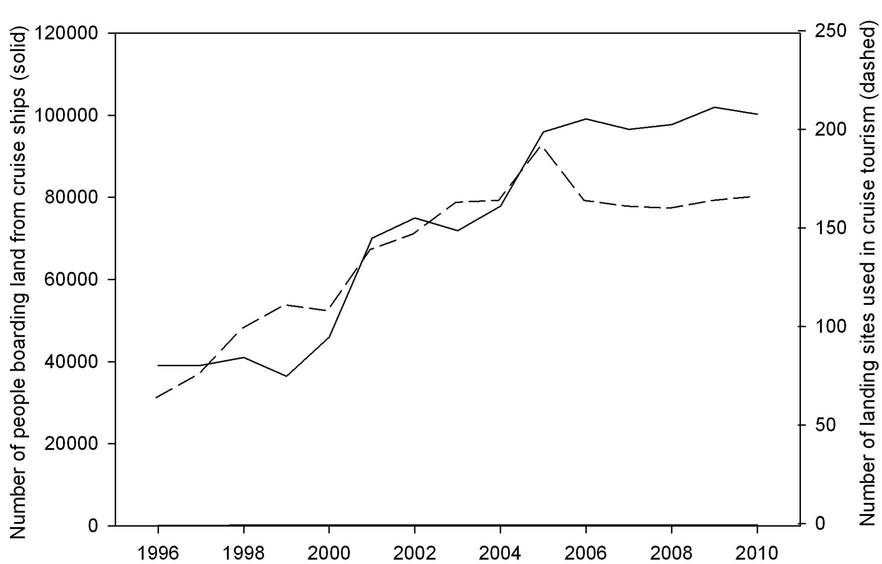

Fig. 2 Cruise ship activities in Svalbard between 1996 and 2010, expressed by the total annual numbers of visitors on land and number of landing sites throughout the archipelago, including the Isfjorden area. Note that the number of people on land represents the cumulative number of landings, and one person could have several landings during one cruise visit to Svalbard. Data source: Office of the Governor of Svalbard.

Citation: *Polar Research* 2012, *31*, 18432, http://dx.doi.org/10.3402/polar.v31i0.18432

visited sites tends to have a radial impact pattern, with impact decreasing towards the periphery, and is influenced by a combination of the focal attraction of the site and other reasons visitors' might have for visiting it. Frequently visited sites with multiple attractions can develop use patterns with high impact immediately surrounding attractions (or nodes), which are connected by routes (linkages). Other factors also influence the relationships between environmental or social impact and visitor density, including the environmental vulnerability of the site (Graefe et al. 1990). The assessment of visitors' impacts on Svalbard's landing sites therefore needs to investigate visitors' behaviour, and not just the total visitor load.

The social impact, or human perceptions of visitors' impacts at sites, is an important aspect that is not as easy to quantify as the impact on vegetation and soils. For example, visitors react more negatively to vandalism and littering than they do to moderate wear patterns on the ground (Kuss et al. 1990; Cole & Hall 2009). Social tolerance of encountering other visitors at sites can also be quite low, especially in wilderness areas (Clark & Stankey 1979a; Watson et al. 2007; Cole & Hall 2009; Vistad & Vorkinn 2012).

As mentioned earlier, Svalbard's plan for the management of outdoor recreation and tourism (Ministry of Environment 1995) was based on the Recreational Opportunity Spectrum (ROS) concept. ROS was the first ambitious and influential American visitor management model, developed partly because the US Forest Service (as a management authority) needed a tool for better integration of resource and visitor management (Clark & Stankey 1979b). ROS was founded on the premise that all kinds of visitation and human activity in nature have an ecological and social impact, but not all of these impacts are controversial or significant (Clark & Stankey 1979b). The subsequent management model Limits of Acceptable Change (LAC) addresses what kind of human activities are preferable or tolerable, under what conditions and how much environmental change (due to these activities) can be accepted before some management action should be implemented in order to limit, stop or repair the actual environmental change. Clark & Stankey write, "In considering what constitutes appropriate or inappropriate impact, it is helpful to distinguish between the *magnitude* of impact and its *importance*" (1979b: 34; original emphases). Scientific knowledge and value judgements must be combined when standards for "acceptable change" are to be decided. Site-specific knowledge about the ecology and cultural heritage of the location, and social conditions (who the visitors are, local behaviour, reasons for visiting, whether groups are guided, etc.), as well as broad stakeholder involvement are crucial within an LAC framework and within knowledge-based management in general.

Values, vulnerability and normative management decisions

Conflicts within nature management are inextricably tied to the concept of value. This is a complicated and challenging concept because the term is perceived differently within different disciplines (Erikstad et al. 2008). At the level of the individual, values "serve as guiding principles in peoples's lives", strongly influencing a person's attitudes and preferences (Schwartz 1994: 88; see also Manfredo et al. 2004). At the level of groups or social institutions, values are related to societal norms and culture, and they guide political goals and priorities (see Lehman 1977; Ritzer 1992).

Individual values and personal preferences come into play when leisure travellers are considering Svalbard as their destination. With their diverse values and interests, visitors seek different experiences at this destination concerning accessibility, social interaction, wilderness qualities, tolerance for environmental impacts and so on (Butler & Waldbrook 2003). At a higher level, values of the wider society are put into action when, for example, Norwegian politicians have decided that coal mining, tourism and scientific research shall be the economic pillars of Svalbard and at the same time the archipelago shall be "one of the best managed wilderness areas in the world" (Ministry of Justice and the Police 2008–09: 9). The day-to-day practice of nature management involves making normative choices based on these partly conflicting political priorities, environmental policy, local management culture and evidence about what kinds of nature and which recreational opportunities should be given priority (Roggenbuck et al. 1993). The critical step of determining the limits of acceptable change in the LAC model (and in any other integrated planning or management model) must be based on a combination of ideal goals, scientific knowledge and pragmatic decisions, since several political goals are to be combined. The result is usually a geographical differentiation (zones) where various political goals ("values") are given different priority in each zone category (Manning 2004; UNEP 2007). The aforementioned plan for the management of outdoor recreation and tourism in Svalbard (Ministry of Environment 1995) is based on this kind of zonation.

Like the concept of value, the notion of vulnerability is used differently by different disciplines, and the border between scientific and normative (value-based) judgments is not always obvious (Kværner et al. 2006). In ecology, the terms sensitivity and fragility are sometimes used instead of vulnerability (Kværner et al. 2006). We have chosen to define vulnerability as "likelihood of change" or "degree of sensitivity of habitats, communities and species to environmental change", in accordance with Nilsson & Grelsson (1995). The terms "tolerance" (the ability of a system to withstand influence without being damaged) and "resilience" (the ability of a system to return to its original stage following a disturbance) cover a similar ecological understanding (Elmqvist et al. 2003; Speed et al. 2010). In this way vulnerability is differentiated from value judgement, as the likelihood of change is not affected by the value (good or bad) of the measured effect. Vulnerability is related to the type, extent and intensity of the influence (see, e.g., Speed et al. 2010). If a species or an ecosystem is disturbed (e.g., as a result of human trampling or pollution), the ability of the species or ecosystem to recover over time (resilience) is an essential question.

A relevant example of vulnerability classification is the Red List of Threatened Species, which contains risk assessments for species extinction (IUCN 2005a). But the Red List is also influenced by normative judgments, where a clear distinction between science and political (or value) judgement is less obvious (Jørstad & Skogen 2010). The Red List presents a list of threatened or rare species that are given higher management priority compared to other species. Today there is no equivalent Red-List system available for vulnerability assessment of sites in Svalbard.

Vegetation and terrain in Svalbard

Effects of human traffic on vegetation and terrain

With more than 170 species of vascular plants, 370 species of bryophytes, 600 species of lichens and 700 species of fungi, Svalbard has high species diversity compared to other Arctic areas at similar latitudes (Elvebakk & Prestrud 1996). The West Spitsbergen Current, which carries warm water along the western coast of Spitsbergen, shapes the climatic conditions that make the western fjords the most favourable for vegetation and terrestrial ecosystem productivity in the archipelago. There are numerous landing sites for cruise ships on the western side of the island (Fig. 1; Elvebakk 2005).

The recovery rate for most Arctic plant communities is generally very slow and any disturbance effects on vegetation are likely to persist for long time. The vulnerability of vegetation to disturbance depends on both its tolerance and its resilience (Strandberg 1997; Speed et al. 2010): wet, flat, small and fine-grained soil sites in general recover better than sloping, dry and coarse-grained sites (Klokk & Rønning 1987; Speed et al. 2010). Sites with moderately dry and coarse soils also generally tolerate trampling better than sites with wet and fine-grained soils, and different soil types often occur in a small-scale mosaic in Arctic vegetation. Arctic landscapes are often characterized by ecological conditions that vary greatly within short distances, implying large variation in vulnerability within a single visitor site and complicating management at the level of individual landing sites.

The effects from human traffic on Arctic vegetation depends on the actual activity (type, intensity, season) taking place (e.g., Graefe et al. 1990; Monz 2002; Nepal & Way 2007) and physical and ecological conditions at the site (water, soil, plant community, terrain; (Forbes et al. 2001; Jorgenson et al. 2010). The effects of human traffic can be measured and recorded at different scales from single species up to landscapes (Table 1). Distinguishing between moderate and severe disturbance is important in management. Moderate disturbance can cause changes in species composition and abundance, but if the disturbance terminates, e.g., as a result of management actions, the vegetation cover is still present and recovery can occur if physical conditions are favourable. If the disturbance is severe—the vegetation is destroyed and the bare soil exposed to wind and

Table 1 Examples of effects, and measured parameters, on vegetation from human traffic. There is an extended literature describing the mechanism and effects, and a few papers have been selected to illustrate the scales.

Scale	Effects/parameter	Literature
Single species and populations	Mechanical disturbance and death of single plants, can affect total Svalbard population for rare species	Solstad et al. (2010)[a]
Plant community, vegetation cover	Reduced plant cover, increased area of bare ground, shift in relative abundance and species composition	Strandberg (1997), Monz (2002), Speed et al. (2010)[a]
Terrain and soil	Changes in microtopography, compressed soil	Forbes et al. (2001)
Landscape	Visual impressions, changes in geological structures, landforms and geodiversity	Råheim (1992)[a], Jorgenson et al. (2010)

[a]Based on Svalbard data.

Citation: *Polar Research* 2012, *31*, 18432, http://dx.doi.org/10.3402/polar.v31i0.18432

water—further degradation and erosion is more likely than the establishment of a new vegetation cover.

Existing knowledge about vegetation in Svalbard

Scientists have studied flora and vegetation in Svalbard for more than a century (Berggren 1873; Resvoll-Holmsen 1921). Most of the observations records on plant species specimens and reported to Norway's scientific museums and are available at the Global Biodiversity Information Facility (GBIF). While these data are valuable for many scientific purposes, they are largely inadequate as input to site-level management decisions for two main reasons. First, the geographic precision of the reported/collected plant is in general very low (often reported at >10–100 km accuracy). Secondly, field observations are unevenly distributed, with sampling concentrated in a few parts of Svalbard and very low density in most areas (Evju et al. 2010; GBIF 2010). This clustering likely explains the high degree of correlation between rare species occurrence and settlement locations (Hagen & Prestø 2007; GBIF 2010). Of the 170 vascular plant species found in the archipelago, 50 are included in the Svalbard Red List (Solstad et al. 2010). Inadequate information regarding the distribution and abundance for other plant groups (bryophytes, lichens, algae) and fungi has prevented assembling a Red List for these groups in Svalbard (Å. Viken, Norwegian Biodiversity Information Centre, pers. comm.).

Svalbard's vegetation types and plant communities have been described and mapped since the 1960s (Rønning 1965; Brattbakk 1986; Elvebakk 2005; Johansen et al. 2009). Although such studies are clearly an important basis for documenting and describing types and variation, they have not been further developed to define valuable, rare or vulnerable vegetation types. Existing ecological knowledge and general knowledge about values and vulnerability in Arctic and alpine vegetation can work as a baseline to establish a system for classification of Svalbard vegetation types by vulnerability level, level of tolerance and resilience. Lack of detailed distribution maps for rare species, and the definition and distribution of rare or vulnerable vegetation types complicates the management of vegetation in Svalbard.

Vegetation: monitoring data and relevance for management decisions

The lack of monitoring data for Svalbard's vegetation has been pointed out in recent decades (Hop et al. 1998; Auditor General of Norway 2006–07). Occasional studies from Svalbard provide repeated analysis of vegetation, but are neither designed as monitoring programmes nor related to human use (Prach et al. 2010). MOSJ, Svalbard's ongoing comprehensive environmental monitoring programme, did not include botanical data until 2009 (Sander et al. 2006). The last revision of MOSJ included two parameters: general vegetation monitoring related to large-scale environmental influences such as climate and pollution, and effects on vegetation from human traffic at selected landing sites (J.R. Hansen, Norwegian Polar Institute, pers. comm.). Baseline data for these two parameters were collected in 2009; the first re-analysis is scheduled for 2014.

Monitoring the effects of human traffic on vegetation is particularly challenging because the selection of sites and methods for monitoring must contend with variation in use and variation in a site's vulnerability due to environmental conditions. Collecting relevant monitoring data within a limited number of monitoring sites presupposes a broad and multidisciplinary approach.

Svalbard's fauna

Effects of human traffic on animals

Of Svalbard's 19 species of marine mammals three are included in Norway's Red List of threatened species: polar bear (*Ursus maritumus*), walrus (*Odobenus rosmarus*) and harbour seal (*Phoca vitulina*) (Swendson et al. 2010). The same is true for 16 of the 203 bird species found in or around Svalbard (Kålås et al. 2010). None of the 59 recorded species of springtails (Collembola) is threatened (Fjellberg 2010). Red Lists for Svalbard have not been worked out for other animal groups represented in the archipelago. Few studies have investigated animal species-specific responses to different types of human activity in Svalbard (see Overrein 2002; Aastrup et al. 2005; Vistad et al. 2008). Nonetheless, using the literature and researcher interviews, it is possible to make a rough grading (e.g., unlikely; possible; likely) of the likelihood of negative responses to disturbance for different groups of birds and mammals.

Disturbance studies are often completed at very different scales (Table 2). Most often disturbance studies focus on individual responses at a very local scale, with little attention to effects at regional scales and cumulative population effects. Although some studies manage to link (local) physiological responses to (cumulative) reproductive responses (e.g., Beale 2007), there is not necessarily an immediate link between responses at local level to effects at population level for species in general.

Most studies that group species into disturbance-likelihood categories address animal responses to

Table 2 Examples of disturbance effects, and measured parameters, on fauna responding to human activity at three different scales.

Scale	Effects/parameters	Literature
Local responses	*Local effect:* focus on absolute responses in animal behaviour or physiological state, i.e., increased heart rates, changed hormone levels, increased attention and possible reduced time spent feeding	Gabrielsen (1987), Colman et al. (2001), Andersen & Aars (2008), Madsen et al. (2009)
Regional responses I	*Regional effects:* focus on distribution of animals over time, i.e., shift in relative abundance as repeatedly short allocations or as area abandonment (avoidance)	See reviews by Gill (2007), Vistnes & Nellemann (2008), Wolfe et al. (2000)
Regional responses II	*Cumulative effects:* focus on changes in reproduction, survival and population size (demographic effects)	Few studies because difficult to carry out, demand long monitoring, and effects often manifest in long-distance of disturbance, but see Gill et al. (2001) and Nellemann et al. (2001)[a]

[a]No studies at this scale from Svalbard.

motorized traffic, and not to people on foot, leaving a knowledge gap for managing Svalbard's visitor landing sites, where people mostly move on foot. Responses of animals to people on foot versus moving in motorized vehicles can be quite different. For example, comparing the responses of Svalbard reindeer (*Rangifer tarandus platyrhynchus*) to motorized traffic (Tyler & Mercer 1998) and to humans on foot (Colman et al. 2001) reveals that the animals show greater aversion to the latter.

From an ecological point of view disturbance from human traffic can be defined as negative when it has an effect at the population level. Any measured responses without population effects touch on the ethical dimensions of disturbance. If absolute "undisturbed" is a goal, then any responses to human presence have relevance (Vistad et al. 2008). While many studies focus primarily on individual behavioural or physiological responses to disturbance, we argue that only cumulative effects at the population level (i.e., effects on reproduction and mortality) should be regarded as the most relevant indicator of change. This is consistent with the ecosystem approach. Species that have both a "high" score in terms of their likelihood of being disturbed and a "high" conservation (Red List) status have the most pronounced need for management priority, for example, at visitor sites. Site-specific registrations of species could result in higher priority for regulations at sites where Red-listed species that are highly likely to be disturbed are recorded.

Fauna: monitoring data and relevance for management decisions

The terrestrial animals of Svalbard—Arctic fox (*Vulpes lagopus*), Svalbard reindeer and Svalbard rock ptarmigan (*Lagopus muta hyperborea*)—are included as indicators in the MOSJ monitoring programme, as are populations of four species of marine birds: common eider (*Somateria mollissima*), common guillemots (*Uria aalge*), Brünich's guillemot (*Uria lomvia*) and black-legged kittiwake (*Rissa tridactyla*) (Norwegian Polar Institute 2011). MOSJ is not designed to test species-specific responses to human activity, and only one (common eider) of the most disturbance-sensitive species (ground nesting birds) are included. Some information from existing monitoring (mainly what MOSJ gathers) could, however, contribute to documenting long-term changes in relation to human activity when used together with site-specific knowledge of human traffic. However, studies that investigate cause–effect relations must be specially designed for that purpose. Systematic recordings of species observations at some of the most visited sites could serve as a kind of monitoring tool, but this sort of data collection is subject to many artefacts that undermine its reliability in documenting changes in animal population sizes over time.

In our view, the existing literature on animal responses to human disturbance provides an adequate foundation for identifying Svalbard's most vulnerable visitor sites with regard to the potential for disturbing wildlife, and for developing management priorities and a management framework. However, site-specific management is not possible without knowledge of species abundances at the individual sites. Such information is available for only a limited number of visitor sites at Svalbard.

Cultural heritage in Svalbard

Effects of human traffic on historical remains

Remains of earlier human activity are often the main attraction at Svalbard's visitor sites. They are highly visible in the open landscape, attracting attention and testifying to the capacity of people to cope with tough conditions. Among the historical relics are the remains of blubber trying furnaces and small houses from the whaling industry in the 17th century, trapper huts from the 18–20th centuries, and mines, buildings, machinery and other artefacts from the mining industry in the 19–20th centuries (Arlov 2003). Historical relics are vulnerable to the effects of present human use (Pearson et al. 2010), in addition to the continual wear caused by Svalbard's harsh physical conditions (Flyen 2009). Unlike a landscape's biotic features, historical structures cannot recover from disturbance, and they lose authenticity if restored. Svalbard has no indigenous population, but people from many countries have used the archipelago for over 400 years, making Svalbard's cultural sites an international heritage.

Assessing the vulnerability of a historical site involves considering both a site's general appeal and the degree to which it awakens an awareness among the visitors as well as a site's heritage value and the technical condition of the structures (Hübner 2009; Table 3). The technical condition of a historic structure is essential to classify its vulnerability. For example, decayed wood collapses easily when stepped on. When evaluating the heritage value of a specific site the most valuable features within the site are described and the changes can be clarified (Directorate for Cultural Heritage 2009). There are several distinct categories of heritage value. Authenticity and experience are regarded as the most important values in Svalbard (Dahle et al. 2000). The state of the structures also influences the comprehension of the site: visitors have an easier time understanding a standing historic structure than a pile of driftwood or rubble. The existing data on the historical value and the physical condition of the remains at Svalbard's cultural heritage sites are not detailed enough to use for assessing their vulnerability level (Dahle et al. 2000).

Existing knowledge of cultural heritage in Svalbard: status and relevance

Historical remains in Svalbard have been mapped and surveyed for more than four decades (Dahle et al. 2000). Diaries, logs and archaeological surveys have provided lots of data about Svalbard's history (Arlov 2003), but data concerning the technical state of historical structures and their vulnerability to human use are sparse. There are no data addressing visitors' awareness and understanding of Svalbard's historic sites. Microclimate in materials and constructions of wooden structures found on Svalbard can be surprisingly favourable for biological activity and decay (Mattsson et al. 2010).

Norway has developed a system for condition analysis of its mainland historic buildings and structures (Norsk Standard NS 3423 2004). The system has been used at a small scale in Svalbard, but it is mainly designed to handle complicated buildings and structures and is therefore not very useful for analysing the decaying remains often found at Svalbard.

MOSJ (Sander et al. 2006) was intended to include data concerning degradation and human use of historical structures in Svalbard, but no cultural heritage data have been added to the database since 1998. Using aerial photography, the Governor of Svalbard monitored archaeological sites from 1998 to 2004. These data have not yet been collected in a database or sufficiently analysed. Moreover, the monitoring period has been too short to reveal changes through time (Auditor General of Norway 2006–07).

Criteria need to be developed to measure site vulnerability. Further development of the existing system used to analyse the condition of historical buildings and structures can be a useful basis for this. The lack of precise data concerning the technical condition of the historic structures and the historic values of the sites makes it impossible to develop site-specific management actions at present state. Considering today's lack of data and the fact that the effects of human use vary within and between sites it is necessary to visit each historical site in order to evaluate its vulnerability.

Achieving knowledge-based management in Svalbard

The future management of Svalbard—and many other Arctic regions—presents a number of important

Table 3 Examples of documented effects of human traffic on cultural heritage and historical remains.

Scale	Effects	Literature
Artefacts, objects	Elimination of artefacts/objects (souvenir gathering), mechanical disturbance or damage, and subsequently bits and pieces blown away	Bjerck (1999)[a]
Cultural monuments	Mechanical disturbance or damage of historic structures, reduced plant cover, sand drift and sand cover on the site/ruin	Arlov & Reymert (2000)[a]
Historic site	Mechanical disturbance, damage of plant cover within the site, changes in geological structures, creating paths, causing landslides on slopes	Kværner et al. (2006), Pearson et al. (2010)

[a]Based on Svalbard data.

challenges: there are a range of political goals to be achieved, involving many legitimate stakeholders, and tourism must find balance between its activities and its ambitions for sustaining the Arctic wilderness (UNEP 2007). The Auditor General of Norway (2006–07) has stated the need for a comprehensive new plan for Svalbard. We contend that a shift towards a more integrated and evidence-based management will contribute to more trusted and reliable, and thereby acceptable, decisions in the management of growing tourism activity at Svalbard.

Knowledge status and knowledge barriers

The amount and quality of relevant data vary considerably, particularly when it comes to monitoring data. There is a certain level of basic knowledge available and, despite its limitations, we are confident that this knowledge can be used to develop a consistent framework to evaluate vulnerability at individual sites. However, the lack of site-specific data makes it difficult to use this knowledge in the management of single locations or groups of similar locations, i.e., as a tool for developing site-specific guidelines. In Svalbard, several institutions, as well as tourism operators, can contribute site-specific data related to land use, attractions, preferences, local behaviour and so on.

To reduce barriers for utilizing the existing knowledge, management authorities and other relevant users and decision makers need to have legal and technical access to all relevant data and they need to know where to find the data and have the time to refine them and put them into context. Data are available from a large variety of sources and in very different shapes. It is impossible to extract and use all available knowledge in day-to-day management and this is a particular challenge in Svalbard, where fixed-term employment produces pronounced staff turnover in the Governor's office. Establishing databases in which to collect the available information, and implementing routines for systematically updating the material, could streamline and improve management efforts.

Site-specific management

Both Svalbard's tourism activities and its natural environment are characterized by variation: sites have a wide range of abiotic conditions, species present, ecosystem attributes and historical remains, and are being visited by groups that differ with respect to size, timing, behaviour, knowledge levels and other characteristics. We use two visitor sites from the west coast of Svalbard as examples to illustrate this variation and the need for site-specific management: Trygghamna in Isfjorden and London in Kongsfjorden (Fig. 1).

One of the most visited sites in Svalbard, Trygghamna witnessed an increase from 850 to 2700 visitors per year between 2001 and 2009 (Fig. 3). This site has several attractions distributed over a large area, including historical remains dating from different periods (17th century whale-hunting, 18th century hunting by Russians, 20th century trapping by Norwegians) and a large bird-cliff (Norwegian Polar Institute 2007; own data). There are no restrictions to use, beyond general Svalbard regulations. Most visitors spend a few hours at this site, taking short walks between the attractions or staying in a very limited area. Some years there is also a camp near some of the cultural remnants. Traces of paths can be seen near some of the attractions but at present Trygghamna exhibits limited visible effects of tourism. However, some types of behaviour are potentially detrimental: artefacts and cultural remains can easily be moved, removed or destroyed, intentionally or inadvertently; birds nesting on the ground are easily accessed and disturbed; some paths have developed in vegetation types that have low tolerance to trampling.

London (Peirsonhamna) has also experienced an increase in visitors: from 700 to about 1500 per year between 2001 and 2009. London features remnants of a small marble mining settlement established in the early 1900s (Norwegian Polar Institute 2007). The remnants are well preserved and it is possible to visit the quarry and the crane by walking along the processed stone paths originally constructed as a railway line (Fig. 4). There are no restrictions in use, beyond general Svalbard regulations. The cabins are closed for visitors, but can be used by residents of nearby Ny-Ålesund for recreational purposes. Most visitors come by boat and stay for an hour or two, but a few groups of visitors hike from a permanent camp located a few hours walking distance away. This site is more vulnerable than Trygghamna: the main access route—a slope between the shoreline and the buildings—has fine-grained soil and a thin vegetation layer with very low tolerance to trampling. Natural erosion processes combined with increased human-caused erosion will gradually undermine the stability of the buildings.

Effective site-specific management requires identifying a site's vulnerable elements. Our own site surveys revealed that the vulnerable elements cover a small part of the total area in a majority of landing sites. Some environmental elements are present during a limited period of the year (nesting birds), and some are easy to identify for visitors (charismatic species, and some

Fig. 3 Trygghamna, in the western part of Isfjorden, is one of the most popular landing sites in Svalbard and has experienced a marked increase in visitors since 2001. The site has diverse historic remains and nature qualities, but is not a particularly vulnerable site. Photo: Kari Sivertsen, Norwegian Institute for Nature Research.

Fig. 4 London, in Kongsfjorden, is a fascinating site with remains from a rather unsuccessful and short-lived history of marble quarrying. The site has experienced increased visitor numbers during the last decade, and part of the site is very vulnerable to human traffic. Photo: Dagmar Hagen, Norwegian Institute for Nature Research.

cultural monuments), while others are not (such as most plant and insect species, decaying historical relics, special soil attributes). Both examples profiled here experienced large increases in visitor numbers over the last years, a trend that could either continue or terminate. The Governor of Svalbard does not wish to regulate the number of visitors travelling to Svalbard and has so far only regulated the number of visitors per landing in exceptional circumstances (e.g., in Virgohamna). This is different from Antarctica, where visitation is partly regulated through the tourism industry's Site Visitor Guidelines and the Antarctic Treaty (Johnston 1997). This unwillingness to limit the number of visitors in Svalbard underscores the need for site-specific information concerning visitor behaviour and the vulnerability of nature and cultural heritage. The level of management regulations (total prohibition of visits as the most extreme) must be appropriate to handle the relevant problems and sites. A management strategy that is too general and neglects local variation will not be able to prevent critical negative impact at the most vulnerable sites and will needlessly restrict activity in more tolerant and resilient sites.

Foundation for an improved management system

Integrated planning frameworks for wilderness management like LAC (Stankey et al. 1985), ROS (Clark & Stankey 1979b) and Visitor Impact Management (Graefe et al. 1990), provides models that are adaptive, guided by objectives and based on knowledge (Manning 2004). They require a satisfactory basic understanding of both environmental and social aspects, with knowledge about vulnerability being a key issue. Management objectives must be reviewed and given priority in accordance with the planning mandate, and the planning process must feature good relationships between involved parties: managers, policy-makers, researchers and other relevant stakeholders (Stankey & McCool 2004). Using these planning models, parties can achieve a high level of consensus in cases that require an innovative approach for resolution if the key challenges are clearly identified, and the environmental and social qualities are measured with agreed-upon indicators. Parties also need to reach agreement on the critical levels or standards for these indicators—"limits of acceptable change"—and implement a monitoring programme to help determine whether, or when, management actions are necessary. To develop, or decide upon, acceptable condition standards, scientific and stakeholder knowledge has to be integrated, and related to management objectives.

Within the past decade, strategies for protecting natural resources in Norway have shifted from simply establishing national parks and other protected areas to placing greater emphasis on managing these areas (Ministry of Environment 2009–10). This shift is partly due to the 2009 Nature Diversity Act, which states that natural resources management must be evidence-based. The "management steered by objectives" ("målstyrt forvaltning" in Norwegian; Gundersen et al. 2011) approach that has recently been introduced to mainland Norway also seems to have reached Svalbard. This calls for more detailed knowledge to formulate plans and address the "right level" of regulations as well as developing targeted tools.

The Norwegian Ministry of Environment initiated the Governor's process of making management plans for all the national parks and nature reserves in Svalbard: "The plans shall contribute to strengthening the knowledge base, and ensure that management has a solid scientific founding" (letters dated 3 June 2009 and 14 July 2010; our translation). While the new Nature Diversity Act for Norway does not apply to Svalbard, the order from the Ministry states the necessity of a precautionary management approach in Svalbard when sufficient knowledge is missing.

The precautionary principle states that the decision-making must be based on the best available information, including that related to human drivers of threats, and traditional and indigenous knowledge (IUCN 2005b). Management will always need new knowledge, since new questions rise and new situations occur; consequently there will always be an interaction between precautionary management decisions and knowledge-based management. The optimal situation is when all stakeholders are confident that all existing knowledge—including knowledge of local residents—is used and the process results as a formal decision. Conflicts might easily occur if involved stakeholders feel that the precautionary principle has been a substitute for using existing knowledge, in particular if the policies are perceived to conflict with sustainable management and economic development (Scott 2001; Cooney 2004). Risk analysis and environmental impacts from shipping and expedition cruise traffic around Svalbard have identified large oil spill as the largest threat to the coastal and marine ecosystem, but reports state that the risk and probability for such accidents is relatively low (Evenseth & Christensen 2011; Norddal 2011). Oil spill scenarios also clearly illustrate the challenge of balancing a precautionary approach with probability and the need to develop a knowledge-based management strategy.

Citation: *Polar Research* 2012, *31*, 18432, http://dx.doi.org/10.3402/polar.v31i0.18432

Management tools

When unacceptable effects from human activity are either very likely or have already occurred, management intervention can be the next step. Determining the need for such intervention can be subjective and can depend on both personal attitudes and different stakeholder perspectives (Vistad 1995; Hagen et al. 2002). The goal of intervention can be to prevent further negative effects or to restore a desired condition (Vistad et al. 2008). Several tools or techniques are available in practical management (Anderson et al. 1998; UNEP 2007). Here we comment on some tools that we consider particularly relevant for Svalbard.

Marked paths channel human traffic and can thereby either reduce the risk of increasing the geographical distribution of ground impact or direct traffic away from especially vulnerable heritage sites or fauna habitats. Physical installations, such as fences and information boards, can produce similar effects. However, we found that none of the involved stakeholders in Svalbard are interested in installing such infrastructural elements—not the managers, the tourism operators nor remote area visitors (Governor of Svalbard 2006; Hagen et al. 2012). There is a similar lack of support among stakeholders for the installation of information signs by cultural heritage monuments (Dahle et al. 2000). Compared to Greenland and Iceland (Høgvard 2003), negative views towards physical measures such as fences and information boards are pronounced in Svalbard. Such attitudes are likely a product of the culture of Norwegian management, where such installations are seen more as a service for visitors than a way of protecting environmental qualities (Høgvard 2003; Vistad et al. 2008). Yet, at some of the most popular and vulnerable sites in Svalbard (Virgohamna and Magdalenefjorden) fences, trails and information boards have been implemented due to a pressing need (Governor of Svalbard 2006).

Visitor behaviour can be strongly influenced by site-specific behaviour guidelines (Scioscia et al. 2009), codes of conduct (Mason 1997; AECO 2011) and well-qualified guides (UNEP 2007). Licensed guides and tour operators should be held directly responsible for both resource protection and visitor safety (UNEP 2007). Establishing criteria for guide qualifications could be especially effective in Svalbard, where the great majority of tourists travel with a guide. Landau & Splettstoesser (2007) and the Governor of Svalbard (2006) highlight the potential and effects of self-regulation, knowledge and caution within the polar tourism industry.

Priority of vulnerable sites

The most vulnerable sites, or those having the highest risk of incurring negative or unacceptable impact from human traffic, must be given the highest priority in local management. Determining which sites receive priority will require a system that helps identify and quantify the level of vulnerability both within and between sites. Vulnerability at individual sites can differ tremendously according to variation in vegetation, fauna and cultural heritage. Future research related to Svalbard management needs to address specific on-site challenges concerning a system for classification of vulnerability. Knowledge that is both empirically based and sufficiently broad, including that held by local residents, should be the baseline for differentiating between sites.

Concluding remarks

Tourism is a politically desired activity in Svalbard, and at present resource managers are reluctant to limit number of visitors to the archipelago. This situation generates a pressing need for knowledge-based management strategies to shape sound, rational and trusted policies. The great variation—between and within sites—in visitation levels and vulnerability to damage calls for a site-specific and adaptive management approach. Site-specific management objectives and planning frameworks enable managers to assess the level of vulnerability or robustness of individual visitor sites. Both scientific research and stakeholder input are essential for matching management strategies with sites and their visitors. Neither natural nor social conditions are invariant, and new management challenges will produce a continuous demand for updated knowledge and a balance between precautionary management and adapted knowledge-based decisions.

Acknowledgements

The authors want to thank the Svalbard Environmental Protection Fund for providing funding to support this work. Svalbard Tourism, the Association of Arctic Expedition Cruise Operators and the Governor of Svalbard have contributed important information about tourism, operators and management. The Governor of Svalbard has also provided statistics from the visitor sites. Thanks to three anonymous reviewers for very valuable comments that improved the manuscript. Thanks also to Erik Stange, Norwegian Institute for Nature Research, for improving the language, and to Kari Sivertsen and Stefan

Blumenrath, at the same institution, for allowing us to use the photograph of Trygghamna and for producing the map.

References

Aarskog K.N. 2008. Et dramatisk forslag. (A dramatic suggestion.) *Svalbardposten 60*, 6–7.

Aastrup P.J., Egevang C., Tamstorf M.P. & Lyberth B. 2005. *Naturbeskyttelse og turisme i Nord- og Østgrønland. Faglig rapport fra DMU 545. (Nature conservation and tourism in north and east Greenland. DMU Report 545.)* Copenhagen: National Environmental Research Institute of Denmark.

AECO (Association of Arctic Expedition Cruise Operators) 2011. *AECO'S guidelines for expedition cruise operations in the Arctic*. Longyearbyen: Association of Arctic Expedition Cruise Operators.

Andersen M. & Aars J. 2008. Short-term behavioural response of polar bears (*Ursus maritimus*) to snowmobile disturbance. *Polar Biology 31*, 501–507.

Anderson D.H., Lime D.W. & Wang T.L. 1998. *Maintaining the quality of park resources and visitor experiences. A handbook for managers*. St. Paul: Department of Forest Resources, University of Minnesota.

Arlov T.B. 2003. *Svalbards historie 1596–1996. (The history of Svalbard 1596–1996.)* Oslo: Aschehoug.

Arlov T.B. & Reymert P.K. 2000. *Kulturminner, kulturmiljø, kulturlandskap. Rapport fra en feltekspedisjon på Svalbard i juli 2000. (Cultural remains, cultural environment, cultural landscape. Report from a field expedition in Svalbard in July 2000.)* Longyearbyen: Office of the Governor of Svalbard.

Auditor General of Norway 2006–07. *Riksrevisjonens undersøkelse av forvaltningen på Svalbard. (Office of the Auditor General of Norway investigation of management in Svalbard.) Dokument 3:8.* Oslo: Office of the Auditor General of Norway.

Beale C.M. 2007. Managing visitor access to seabird colonies: a spatial simulation and empirical observations. *Ibis 149*, 102–111.

Berggren S. 1873. *Spetsbergens mossvegetation. (The moss vegetation of Spitsbegen.) Botaniska Notiser*. Lund: Lund Botanical Society.

Bjerck H.B. 1999. *Overvåking av kulturmiljø på Svalbard. Målsetting, metode og overvåking. (Monitoring historic sites at Svalbard. Aims, methodology and monitoring.)* Longyearbyen: Office of the Governor of Svalbard.

Brattbakk I. 1986. *Vegetasjonsregioner—Svalbard og Jan Mayen. Nasjonalatlas for Norge. Kartblad 4.1.3. (Vegetation regions—Svalbard and Jan Mayen. National atlas of Norway. Map sheet 4.1.3.)* Hønefoss: Norwegian Mapping Authority.

Butler R.W. & Waldbrook L.A. 2003. A new planning tool: the tourism opportunity spectrum. *Journal of Tourism Studies 14*, 21–32.

Clark R.N. & Stankey G.H. 1979a. Determining the acceptability of recreational impacts: an application of the outdoor recreation opportunity spectrum. In R. Ittner et al. (eds.): *Recreation impact on wildlands. Conference proceedings, October 27–29, 1978, Seattle, Washington*. Pp. 32–42. Seattle: Pacific Northwest Region, US Forest Service.

Clark R.N. & Stankey G.H. 1979b. *The recreation opportunity spectrum: a framework for planning, management, and research. General Technial Report PNW-98*. Portland: Pacific Northweset Forest and Range Experiment Station, US Forest Service.

Cole D.N. 2004. Environmental impacts of outdoor recreation in wildlands. In M.J. Manfredo et al. (eds.): *Society and natural resources: a summary of knowledge*. Pp. 107–116. Jefferson, MO: Modern Litho.

Cole D.N. & Hall T.E. 2009. Perceived effects of setting attributes on visitor experiences in wilderness: variation with situational context and visitor characteristics. *Environmental Management 44*, 24–36.

Colman J.E., Jacobsen B.W. & Reimers E. 2001. Summer response distances of Svalbard reindeer *Rangifer tarandus platyrhynchus* to provocation by humans on foot. *Wildlife Biology 7*, 275–283.

Cooney R. 2004. *The precautionary principle in biodiversity conservation and natural resource management: an issues paper for policy-makers, researchers and practitioners*. Gland: International Union for Conservation of Nature and Natural Resources.

Dahle K., Bjerck H.B. & Prestvold K. 2000. *Kulturminneplan for Svalbard 2000–2010. (Cultural heritage plan for Svalbard 2000–2010.)* Longyearbyen: Governor of Svalbard.

Directorate for Cultural Heritage. 2009. *Kulturhistorisk stedsanalyse. En veileder i bruk av DIVE. (Historical analyses of localities. A guide for using DIVE.)* Oslo: Directorate for Cultural Heritage.

Elmqvist T., Folke C., Nystrom M., Peterson G., Bengtsson J., Walker B. & Norberg J. 2003. Response diversity, ecosystem change, and resilience. *Frontiers in Ecology and the Environment 1*, 488–494.

Elvebakk A. 2005. A vegetation map of Svalbard on the scale 1:3.5 mill. *Phytocoenologia 35*, 951–967.

Elvebakk A. & Prestrud P. (eds.) 1996. *A catalogue of Svalbard plants, fungi, algae and cyanobacteria. Norsk Polarinstitutt Skrifter 198*. Tromsø: Norwegian Polar Institute.

Erikstad L., Lindblom I., Jerpåsen G., Hanssen M.A., Bekkby T., Stabbetorp O. & Bakkestuen V. 2008. Environmental value assessment in a multidisciplinary EIA setting. *Environmental Impact Assessment Review 28*, 131–143.

Evenseth A. & Christensen G.N. 2011. *Enviromental impacts of expedition cruise traffic around Svalbard*. Tromsø: Akvaplan-niva.

Evju M., Blumentrath S. & Hagen D. 2010. *Nordaust-Svalbard og Søraust-Svalbard naturreservater. Kunnskapsstatus for flora og vegetasjon. (Nordaust-Svalbard and Søraust-Svalbard nature reserves. State of knowledge for flora and vegetation.) Norwegian Institute for Nature Research Report 554*. Oslo: Norwegian Institute for Nature Research.

Fjellberg A. 2010. Collembola. In J.A. Kålås et al. (eds.): *The 2010 Norwegian Red List for species*. Pp. 347–354. Trondheim: Norwegian Biodiversity Information Centre.

Flyen A.-C. 2009. Coastal erosion—a threat to the cultural heritage at Svalbard? *Polar Research in Tromsø 2009*, 13–14.

Forbes B.C., Ebersole J.J. & Strandberg B. 2001. Anthropogenic disturbance and patch dynamics in circumpolar Arctic ecosystems. *Conservation Biology 15*, 954–969.

Gabrielsen G.W. 1987. Reaksjoner på menneskelige forstyrrelser hos ærfugl, svalbardrype og krykkje i egg/ungeperioden. (The impact of human activities on eider ducks, Svalbard ptarmigan and kittiwakes during the breeding season.) *Vår Fuglefauna 10*, 152–158.

GBIF 2010. Global biodiversity information facility. Accessed on the internet at http://www.gbif.no/ on 15 April 2011.

Geelmuyden A.K. 1993. Landskapsanalyse—planredskap og erkjennelsesvei. (Landscape analyses—planning tools and way to acknowledgement.) *Byggekunst 3*, 152–157.

Gill J.A. 2007. Approaches to measuring the effects of human disturbance on birds. *Ibis 149*, 9–14.

Gill J.A., Norris K. & Sutherland W.J. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation 97*, 265–268.

Governor of Svalbard 2006. *Turisme og friluftsliv på Svalbard. Utvikling, politiske føringer, rammebetingelser, utfordringer og strategier. (Tourism and outdoor recreation in Svalbard. Development, political guidelines, frameworks, challenges and strategies.)* Longyearbyen: Office of the Governor of Svalbard.

Governor of Svalbard 2008. Reiselivsstatistikk for Svalbard 2008. (Tourism statistics for Svalbard 2008.) Longyearbyen: Office of the Governor of Svalbard.

Governor of Svalbard 2010. Sysselmannen på Svalbard. (The Governor of Svalbard.) Accessed on the internet at http://www.sysselmannen.no/ on 28 March 2011.

Graefe A.R., Kuss F.R. & Vaske J.J. 1990. *Visitor impact management. The planning framework*. Washington, DC: National Parks and Conservation Association.

Gundersen V., Andersen O., Kaltenborn B.P., Vistad O.I. & Wold L.C. 2011. *Målstyrt forvaltning. Metoder for håndtering av ferdsel i verneområder. (Management by objectives. Methods for handling recreation in protected areas.) Norwegian Institute for Nature Research Report 615*. Lillehammer: Norwegian Institute for Nature Research.

Hagen D., Aasetre J. & Emmelin L. 2002. Communicative approaches to restoration ecology: a case study from Dovre Mountain and Svalbard, Norway. *Landscape Research 27*, 359–380.

Hagen D., Eide N.E., Fangel K., Flyen A.C. & Vistad O.I. 2012. *Sårbarhetsvurdering og bruk av lokaliteter på Svalbard. Sluttrapport fra forskningsprosjektet "Miljøeffekter av ferdsel?" (Vulnerability assessment and use of visitor sites in Svalbard. Final report from the research project Environmental Impact from Human Use?) Norwegian Institute for Nature Research Report 785*. Trondheim: Norwegian Institute for Nature Research.

Hagen D. & Prestø T. 2007. *Biologisk mangfold—temarapport som grunnlag for arealplan for Longyearbyen planområde. (Biodiversity—thematic report as a basis for the land use plan for Longyearbyen.) Norwegian Institute for Nature Research Report 252*. Trondheim: Norwegian Institute for Nature Research.

Høgvard K. 2003. *Miljøovervåking av ferdselsslitasje—Grønland, Island og Svalbard. (Environmental monitoring of human use effects—Greenland, Iceland and Svalbard.) ANP 2003:530*. Århus: Nordic Council of Ministers.

Hop H., Hansen J.R. & Hubert-Hansen J.-P. 1998. *Overvåking av biologisk mangfold i Arktis. (Monitoring biological diversity in the Arctic.) Norsk Polarinstitutt Meddelelser 158*. Tromsø: Norwegian Polar Institute.

Hübner A. 2009. Tourist images of Greenland and the Arctic: a perception analysis. *Polar Record 45*, 153–166.

IUCN 2005a. Guidelines for using the IUCN Red List categories and criteria. Accessed on the internet at http://www.iucnredlist.org/technical-documents/categories-and-criteria on 19 March 2012.

IUCN 2005b. The Precautionary Principle Project. Accessed on the internet at http://cmsdata.iucn.org/downloads/ln250507_ppguidelines.pdf on 19 March 2012.

Johansen B., Tømmervik H.A. & Karlsen S.R. 2009. *Vegetasjonskart over Svalbard basert på satellittdata. Dokumentasjon av metoder og vegetasjonsbeskrivelser. (Vegetation map of Svalbard based on satellite data. Methods and vegetation descriptions.) Norwegian Institute for Nature Research Report 456*. Tromsø: Norwegian Institute for Nature Research.

Johnston M.E. 1997. Polar tourism regulation strategies: controlling visitors through codes of conduct and legislation. *Polar Record 33*, 13–20.

Jorgenson J.C., Hoef J.M.V. & Jorgenson M.T. 2010. Long-term recovery patterns of Arctic tundra after winter seismic exploration. *Ecological Applications 20*, 205–221.

Jørstad E. & Skogen K. 2010. The Norwegian Red List between science and policy. *Environmental Science & Policy 13*, 115–122.

Kålås J.A., Gjershaug J.O., Husby M., Lifjeld J., Lislevand T., Strann K.-B. & Strøm H. 2010. Aves. In J.A. Kålås et al. (eds.): *The 2010 Norwegian Red List for species*. Pp. 419–430. Trondheim: Norwegian Biodiversity Information Centre.

Kaltenborn B.P. & Emmelin L. 1993. Tourism in the High North: management challenges and recreation opportunity spectrum planning in Svalbard, Norway. *Environmental Management 17*, 41–50.

Klokk T. & Rønning O.I. 1987. Revegetation experiments at Ny-Ålesund, Spitsbergen, Svalbard. *Arctic and Alpine Research 19*, 549–553.

Kuss F.R., Graefe A.R. & Vaske J.J. 1990. *Visitor impact management. A review of research*. Washington, DC: National Parks and Conservation Association.

Kværner J., Swensen G. & Erikstad L. 2006. Assessing environmental vulnerability in EIA—the content and context of the vulnerability concept in an alternative approach to standard EIA procedure. *Environmental Impact Assessment Review 26*, 511–527.

Landau D. & Splettstoesser J. 2007. Antarctic tourism: what are the limits? In J.M. Snyder & B. Stonehouse (eds.): *Prospects for polar tourism*. Pp. 197–209. Oxford: CABI Publishing.

Lehman E.W. 1977. *Political society. A macrosociology of politics*. New York: Columbia University Press.

Madsen J., Tombre I.M. & Eide N.E. 2009. Effects of disturbance on geese in Svalbard: implications for management of increasing tourism activities. *Polar Research 28*, 376–389.

Manfredo M.J., Teel T.L. & Bright A.D. 2004. Application of the concepts of values and attitudes in human dimensions of natural resources research. In M.J. Manfredo et al. (eds.): *Society and natural resources: a summary of knowledge*. P. 361. Jefferson, MO: Modern Litho.

Manning R.E. 2004. Recreation planning framworks. In M.J. Manfredo et al. (eds.): *Society and natural resources: a summary of knowledge*. Pp. 83–96. Jefferson, MO: Modern Litho.

Mason P. 1997. Tourism codes of conduct in the Arctic and sub-Arctic region. *Journal of Sustainable Tourism 5*, 151–165.

Mattsson J., Flyen A.C. & Nunez M. 2010. Wood-decaying fungi in protected buildings and structures on Svalbard. *Agarica 29*, 5–14.

Ministry of the Environment 1995. Forvaltningsplan for turisme og friluftsliv på Svalbard. *(Management plan for tourism and outdoor recreation at Svalbard.)* Oslo: Ministry of the Environment.

Ministry of the Environment 2009–10. *Prop. 1 S. Proposisjon til Stortinget (forslag til stortingsvedtak). For budsjettåret 2010. (Prop. 1 S. Proposition to Parliament (proposal for Parliament decision.) For the budget year 2010.)* Oslo: Ministry of the Environment.

Ministry of Justice and the Police 2008–09. *Svalbard. Stortingsmelding nr 22. (Svalbard. White Paper 22.)* Oslo: Ministry of Justice and the Police.

Monz C.A. 2002. The response of two Arctic tundra plant communities to human trampling disturbance. *Jounal of Environmental Management 64*, 207–217.

Monz C.A., Cole D.N., Leung Y.-F. & Marion J.L. 2010. Sustaining visitor use in protected areas: future opportunities in recreation ecology research based on the USA experience. *Environmental Management 45*, 551–562.

Nellemann C., Kullerud L., Vistnes I., Forbes B.C., Husby E., Kofinas G.P., Kaltenborn B.P., Rouaud J., Magomedova M., Bobiwash R., Lambrechts C., Schei P.J., Tveitdal S., Grøn Ø. & Larsen T.S. 2001. *GLOBIO. Global methodology for mapping human impacts on the biosphere. The Arctic 2050 scenario and global application. UNEP/DEWA/TR.01-3*. Nairobi: Division of Early Warning and Assessment, United Nations Environmental Programme.

Nepal S.K. & Way P. 2007. Comparison of vegetation conditions along two backcountry trails in Mount Robson Provincial Park, British Columbio (Canada). *Jounal of Environmental Management 82*, 240–249.

Nilsson C. & Grelsson G. 1995. The fragility of ecosystems: a review. *Journal of Applied Ecology 32*, 677–692.

Norddal T. 2011. *En analyse av sannsynligheten for ulykker ved seilas på Øst-Svalbard. (Risk assessment for accidents related to shipping in eastern Svalbard.)* Trondheim: Ramboll.

Norsk Standard 2004. *Tilstandsanalyse av fredete og verneverdige bygninger. (Condition survey of protected buildings with historical value.) NS 3423.* Oslo: Standard Norway.

Norwegian Polar Institute 2007. *Cruise handbook for Svalbard.* Tromsø: Norwegian Polar Institute.

Norwegian Polar Institute 2011. Cruise tourism. Environmental Monitoring of Svalbard and Jan Mayen—MOSJ. Accessed on the internet at http://mosj.npolar.no/no/influence/traffic/indicators/cruiseturisme.html on 14 April 2011.

Overrein Ø. 2001. *Svalbard—et av de best forvaltede villmarksområder i verden? Prinsipper for god villmarksforvaltning. (Svalbard—one of the best managed wilderness areas in the world? Principles for good wilderness management.)* Tromsø: Norwegian Polar Institute.

Overrein Ø. 2002. *Virkninger av motorferdsel på fauna og vegetasjon. (Effects of motorized traffic on fauna and vegetation.) Norwegian Polar Institute Rapportserie 119*. Tromsø: Norwegian Polar Institute.

Overrein Ø (ed.) 2010. *MOSJ Rapport—ferdsel. (MOSJ report—human traffic.)* Tromsø: Norwegian Polar Institute.

Pearson M., Stehberg R., Senatore M.X. & Gatica C. 2010. Conserving the oldest historic sites in the Antarctic: the challenges in managing the sealing sites in the South Shetland Islands. *Polar Record 46*, 57–64.

Prach K., Kosnar J., Klimesova J. & Hais M. 2010. High Arctic vegetation after 70 years: a repeated analysis from Svalbard. *Polar Biology 33*, 635–639.

Råheim E. 1992. *Registration of vehicular tracks on the Svalbard Archipelago. Norsk Polarinstitutt Meddelelser 22*. Oslo: Norwegian Polar Institute.

Resvoll-Holmsen H. 1921. En del planter fra Sydkaplandet paa Spitsbergen. (Some plant species from Sydkaplandet in Spitsbergen.) *Naturen 44*, 307–314.

Ritzer G. 1992. *Contemporary sociological theory.* 3rd edn. New York: McGraw-Hill.

Roggenbuck J.W., Williams D.R. & Watson A.E. 1993. Defining acceptable conditions in wilderness. *Environmental Management 17*, 187–197.

Rønning O.I. 1965. *Studies in Dryadion of Svalbard. Norsk Polarinstitutt Skrifter 134*. Oslo: Norwegian Polar Institute.

Sander G., Hanssen-Bauer I., Bjørge A. & Prestrud P. 2006. *The Environmental Monitoring of Svalbard and Jan Mayen—MOSJ: documentation of the system and the first assessments of the state of the environment*. Tromsø: Norwegian Polar Institute.

Schwartz S.H. 1994. Beyond individualism/collectivism. New cultural dimensions of values. In U. Kim et al. (eds.): *Individualism and collectivism. Theory, method, and applications*. Thousand Oaks, CA: Sage Publications.

Scioscia G., Rey A.R., Favero M. & Schiavini A. 2009. Colony attendance patterns of Magellanic penguin (*Spheniscus magellanicus*) at Isla Martillo, Beagle Channel, Tierra del Fuego: guidelines to minimize human disturbance. *Ornitoligia Neotropical 20*, 27–34.

Scott S.V. 2001. How cautious is precautious? Antarctic tourism and the precautionary principle. *International and Comparative Law Quarterly 50*, 963–971.

Solstad H., Elven R., Alm T., Alsos I.G., Bratli H., Fremstad E., Mjelde M., Moe B. & Pedersen O. 2010. Karplanter (Pteridophyta, Pinophyta, Magnoliophyta). (Vascular plants [Pteridophyta, Pinophyta, Magnoliophyta].) In J.A. Kålås et al. (eds.): *The 2010 Norwegian Red List for species*. Pp. 155–182. Trondheim: Norwegian Biodiversity Information Centre.

Speed J.D.M., Cooper E.J., Jonsdottir I.S., van der Wal R. & Woodin S.J. 2010. Plant community properties predict vegetation resilience to herbivore disturbance in the Arctic. *Journal of Ecology 98*, 1002–1013.

Stankey G.H., Cole D.N., Lucas R.C., Petersen M.E. & Frissell S.S. 1985. *The Limits of Acceptable Change (LAC) system for wilderness planning. General Technical Report INT-176*. Ogden, UT: Intermountain Forest and Range Experiment Station, US Forest Service.

Stankey G.H. & McCool S.F. 2004. Social sciences and natural resources management. An assessment of advances. A summary of knowledge. In M.J. Manfredo et al. (eds.): *Society and natural resources: a summary of knowledge*. Pp. 21–34. Jefferson, MO: Modern Litho.

Stern M.J. 2008. The power of trust: toward a theory of local opposition to neighboring protected areas. *Society and Natural Resources 21*, 859–875.

Strandberg B. 1997. Vegetation recovery following anthropogenic disturbances in Greenland. In R.M.M. Crawford (ed.): *Disturbance and recovery in Arctic lands*. Pp. 381–390. Dordrecht: Kluwer Academic Publishers.

Sutherland W.J., Pullin A.S., Dolman P.M. & Kneight T.M. 2004. The need for evidence-based conservation. *Trends in Ecology and Evolution 19*, 305–308.

Svalbard Næringsutvikling 1997. *Reiselivsplan for Svalbard—utfordringer og strategier. (Tourist plan for Svalbard—challenges and strategies.)* Longyearbyen: Svalbard Næringsutvikling (Svalbard Commercial Development).

Swendson J.E., Bjørge A., Kovacs K., Syvertsen P.O., Wiig Ø. & Zedrosser A. 2010. Mammalia. In J.A. Kålås et al. (eds.): *The 2010 Norwegian Red List for species*. Pp. 431–440. Trondheim: Norwegian Biodiversity Information Centre.

Tyler N.J.C. & Mercer J.B. 1998. Heart-rate and behavioural responces to disturbance in Svalbard reindeer *Rangifer tarandus platyrhynchus*. In J.A Milne (ed.): *Recent developments in deer biology*. Pp. 233–234. Aberdeen: Macaulay Land Use Research Institute.

UNEP (United Nations Environmental Programme) 2007. *Tourism in the polar regions. The sustainability challenge.* Paris: Sustainable Consumption and Production Branch, United Nations Environmental Program and Washington, DC: The International Ecotourism Society.

Vistad O.I. 1995. *I skogen og i skolten. Ein analyse av friluftsliv, miljøoppleving, påverknad og forvaltning i Femundsmarka, med jamføringar til Rogen og Långfjället. (In the forest and in the head. An analysis of outdoor recreation, recreational experiences, recreational impacts and management in Femundsmarka, compared to Rogen and Långfjället.)* PhD thesis, University of Trondheim.

Vistad O.I., Eide N.E., Hagen D., Erikstad L. & Landa A. 2008. *Miljøeffekter av ferdsel og turisme i Arktis. En litteratur-og forstudie med vekt på Svalbard. (Environmental effects on human traffic and tourism in the Arctic. A review focussing on Svalbard.) Norwegian Institute for Nature Research Report 316*. Oslo: Norwegian Institute for Nature Research.

Vistad O.I. & Vorkinn M. 2012. The wilderness purism construct—experiences from Norway with a simplified version of the purism scale. *Forest Policy and Economics 19*, 39–47.

Vistnes I. & Nellemann C. 2008. The matter of spatial and temporal scales: a review of reindeer and caribou response to human activity. *Polar Biology 31*, 399–407.

Watson A., Glaspell B., Christensen N., Lachapelle P., Sahanatien V. & Gertsch F. 2007. Giving voice to wildlands visitors: selecting indicators to protect and sustain experiences in the eastern Arctic of Nunavut. *Environmental Management 40*, 880–888.

Wolfe S.A., Griffith B. & Wolfe C.A.G. 2000. Response of reindeer and caribou to human activities. *Polar Research 19*, 63–73.