RESEARCH/REVIEW ARTICLE

The impact of human activities on wilderness and aesthetic values in Antarctica

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Abstract

There has been little progress in implementing protection of wilderness and aesthetic values in Antarctica since the coming into force of the Protocol on Environmental Protection to the Antarctic Treaty in 1998. This can in part be attributed to a lack of research defining these values and showing how they may be assessed. In 2009, a survey comprising 90 images of Antarctic landscapes was established on the Internet to canvass as wide a cross-section of people with an interest in Antarctica as possible on their perceptions of wilderness and their aesthetic preference. At the time of writing, over 337 respondents from 23 nationalities have taken part in the survey. Responses were analysed to determine the effect of human presence, both transient and as infrastructure, on perceptions of wilderness and aesthetic values. The analysis was in three parts: (1) all images combined; (2) images grouped by landscape type, derived from the Environmental Domains of Antarctica regionalization; and (3) 16 pairs of digitally manipulated images of which respondents were shown either an original image or one in which human presence had been either digitally removed or added. Responses to images grouped by landscape type show that coastal and ice-free areas are less valued both aesthetically and as wilderness than mountainous and ice-covered terrains. Signs of human presence were found to make images significantly less likely to be considered as wilderness and also reduced their aesthetic rating. This demonstrates that human impacts on these values are measureable.

To access the supplementary material to this article, please see Supplementary Files under Article Tools online.

The Protocol on Environmental Protection to the Antarctic Treaty, also known as the Madrid Protocol, which came into force in 1998, mandates the protection of the wilderness and aesthetic values. Article 3, Environmental Principles, includes the following:

1. The protection of the Antarctic environment and dependent and associated ecosystems and the intrinsic value of Antarctica, *including its wilderness and aesthetic values* and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area.
2. To this end:

(a) activities in the Antarctic Treaty area shall be planned and conducted so as to limit adverse impacts on the Antarctic environment and dependent and associated ecosystems;

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(b) activities in the Antarctic Treaty area shall be planned and conducted so as to avoid:
...
(vi) degradation of, or substantial risk to, areas of biological, scientific, historic, *aesthetic or wilderness* significance. (SAT 1991 [emphases added by author])

Apart from environmental principles, there are two practical ways in which wilderness and aesthetic values are to be protected: through environmental impact assessment procedures, which are laid out in Annex I to the Madrid Protocol, and through Annex V, the Area Protection and Management System (SAT 1991).

The phrasing in Article 3, Section 1, is ambiguous as to whether the authors of the Protocol intended wilderness and aesthetic values to be one or two sets of values. Wilderness values are conventionally thought of as relating to large natural areas undisturbed by human activity whereas aesthetic values relate to perceptions of scenic beauty. This leads to the conclusion that they are separate sets of values, though potentially related in that wilderness areas may have high aesthetic values. For the purpose of determining the impacts of human activities on these values, they are treated separately in the research that is described here, though the relationship between these values is considered further using the evidence of the survey.

Although protection of wilderness and aesthetic values has been discussed at a number of Antarctic Treaty Consultative Meetings and meetings of the Committee for Environmental Protection, the lack of agreed definitions in the text of the Madrid Protocol and the absence of a common understanding of wilderness, as well as more urgent matters, such as management of protected areas and control of non-native species, have resulted in little progress in implementing protection (Harry Keys, pers. comm.). Antarctica is managed by the 28 Antarctic Treaty Consultative Parties (SAT 2012) under the terms of the Antarctic Treaty. Any proposed definition of wilderness and aesthetic value must therefore be acceptable to all Antarctic Treaty Consultative Parties.

Definitions of wilderness and aesthetics

There are precedents for the protection of wilderness in national legislation in many countries that are Consultative Parties to the Antarctic Treaty. Landres et al. (2008) list wilderness protection legislation in 10 countries, the earliest of which is the US Wilderness Act of 1964, the enactment of which stimulated the identification and protection of wilderness and wilderness values on federal lands in the United States. Examples of legislation protecting scenic beauty include the US National Environmental Policy Act of 1969, the National Parks and Access to the Countryside Act of 1949 in England and Wales, and the World Heritage Convention of 1979.

The concept of "wilderness" has changed dramatically in the past 200 years. The history of how the meaning of wilderness changed from the Puritans' biblical dread of the North American wilderness to its modern exaltation as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain" (from US Wilderness Act) has been recounted by a number of environmental historians, for example, Nash (1975) and Oelschlaeger (1991). Even so, wilderness is still a contested idea, not only by environmentalists, for example, Cronon (1995) and Low (2002), but also by critics in developing nations who consider the concept of wilderness to be another form of Western imperialism (Guha 1989).

There are many definitions of wilderness. Washington (2006) reviews many of these and proposes "large natural intact area" (p. vii) as a simple definition that avoids some of the controversies that the idea of wilderness has generated; Callicott & Nelson (1998) include many sides of the debate. Kormos & Locke (2008) refer to wilderness as "the most intact, undisturbed, wild, natural areas—those last truly wild places that humans do not control and have not developed with roads and other industrial infrastructure" (p. 5). The International Union for the Conservation of Nature has published guidelines for applying to protected area categories that specify that, for Protected Area Category 1b (wilderness areas), the distinguishing features should generally "be free of modern infrastructure, development and industrial extractive activity" (Dudley 2008: 14). The presence of infrastructure is therefore one of the key factors in deciding whether or not an area can be designated as wilderness. This is particularly relevant in Antarctica, where there is no history of landscape modification except in a few, very confined localities in and around research stations. It is the presence of infrastructure that defines permanent human presence. As a consequence, it seems reasonable to propose that all of Antarctica can be considered as wilderness unless it has been degraded by some human activity, principally the construction of infrastructure. This proposition has been put forward by a number of authors (Summerson & Riddle 2000; Codling 2001; Summerson 2012).

There is perhaps even greater disagreement about the meaning of the word "aesthetic" and whether it is a synonym for beauty, a theory of beauty, a theory of art or a combination of beauty and art. Its meaning, as defined

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by its creator Alexander Baumgarten in 1735, was "the science of how things are to be cognized by means of the senses" (Guyer 1998: 227). Summerson & Bishop (2011) review the history of aesthetics and argue that it must include reference to the sublime. Bradley (1950) suggests that "beautiful," the sublime and similar terms represent some of the "many modes of beauty" (p. 40). Scruton (2009) notes that "the aesthetic is a realm of *value*" (p. 140; his emphasis). It could therefore be concluded that Bradley's "many modes of beauty" could be re-defined as "aesthetic values".

Research questions and landscape assessment approaches

To facilitate implementation of the Madrid Protocol and protection for wilderness and aesthetic values, a number of research questions need to be answered: What is wilderness in the Antarctic context—and therefore what area or areas can be designated as wilderness? What are aesthetic values in the Antarctic context? How can human impacts on wilderness values be defined and measured? How can human impacts on aesthetic values be defined and measured?

The selection of an approach to answer these research questions should recognize: the nature and duration of people's experience in Antarctica; the level of interest in Antarctica in the general public; the international nature of Antarctica both in terms of individual national commitment in Antarctica and governance; and the tradition of consensus in Antarctic decision-making.

Arthur et al. (1977) suggest that there are three broad approaches to landscape assessment: descriptive inventories, public preference models and economic analyses. The first two approaches include both quantitative and non-quantitative methods. For this study, the descriptive inventory approach was rejected on the basis that, unlike the settled continents with a long history of occupation, Antarctic landscapes are essentially very simple. As Pyne (1987) says, Antarctica's "topography and dynamics [are] the simplest on Earth" (p. 290).

We considered the public preference model of landscape aesthetic assessment, which typically uses perceptual surveys to obtain input from stakeholders, as opposed to assessment by landscape professionals, to be the most suitable approach for Antarctica. In this case, a stakeholder is anyone with an interest in Antarctica, including scientists, policy-makers and operations staff working in national Antarctic programmes, research institutes and universities; tourists, tourism operators and interested members of the general public. Psychophysical methods have become the dominant quantitative approach in landscape aesthetic assessment (Arthur et al. 1977; Daniel 1990, 2001) and these methods have been adopted in this study.

Numerous studies of landscape aesthetics have used photographs (Daniel & Boster 1976; Habron 1998; Wherrett 1999, 2000; Arriaza et al. 2004; Wu et al. 2006). Citing 32 studies that use photographic media, Kaplan & Kaplan (1995) discuss the issue of responses to photographs versus responses to actual scenes at length. They argue that people are sufficiently used to seeing three-dimensional environments reduced to two-dimensional depictions in print and on screen that responses to photographs are "surprisingly similar" (p. 16) to responses to real places, and that site visits may pose a number of logistical problems that are obviated by the use of photographs. This is certainly the case in Antarctica, where it would be logistically impossible to survey any more than a few people at very few sites. Whether the argument of familiarity with two-dimensional views stands in an environment where scale interpretation is not intuitive is a point that has not been tested. However, we had no experience of anyone commenting that they were unable to interpret the photographs used in our survey and so we have accepted the widespread view that photographs are an adequate surrogate for the direct experience of the landscape. The use of digitally manipulated photographs allows the direct comparison of perceptions of wilderness and aesthetic preference from responses to pairs of scenes, which differ only in prescribed, controlled ways (Rodiek & Fried 2005).

The use of the Internet as a medium for conducting landscape preference research has matured since Bishop (1997) investigated its potential for undertaking perception research and Wherrett (1999) for landscape preference research. Reips (2002) has proposed standards for Internet surveys, Roth (2006) has tested the reliability of an Internet survey for visual landscape assessment and found that the results for scenic quality, beauty and naturalness were valid, and Lange et al. (2008) used both a paper-based questionnaire and an Internet survey to obtain preference scores on future scenarios of green space using virtual landscapes. They found few differences between the paper-based questionnaire and the Internet survey.

Definitions of boundaries of wilderness have mostly been carried out using geographical information systems and spatial data such as vegetation type and land use. The National Wilderness Inventory in Australia, for example, used four indicators to define wilderness: remoteness from settlement, remoteness from access, apparent naturalness and biophysical naturalness (Lesslie & Maslen

1995). Dearden (1984), used photographs to evaluate responses to three different land-use types, including wilderness; Habron (1998) used photographs to elicit preference scores for wildness, beauty and naturalness in Scotland; Lutz et al. (1999) used a small set of photographs to study attitudes to and perceptions of wilderness; and Dilworth (2006) provided participants with disposable cameras and asked them to take photographs of settings that represented wilderness. In this study, we used photographs of Antarctic landscapes with human presence at different scales of intensity and proximity to gauge responses to their impact on perceptions of wilderness and aesthetic value and to compare with responses to photographs of solely natural scenes.

Methods

Survey design

The survey comprised 90 digital photographs (73 original, 17 digitally altered, as discussed below) of Antarctic landscapes divided into three sets of 30. When respondents logged onto the survey they were randomly allocated one of the sets. "Dropout" (Reips 2002)—when a respondent leaves the survey before completing it—is a common problem. A number of measures were taken to reduce the chances of dropout and to minimize its effects. A "high-hurdle" technique was adopted by directing the survey towards people with an interest in Antarctica who would therefore be more likely to be motivated to take part and complete the survey. The background page, which includes an extract from the Madrid Protocol and a statement on how respondents' results will be used, provides further motivation. A "warm-up" technique was also adopted by starting the actual evaluation phase eight pages into the survey. Reips (2002) advised that most dropouts occur at the beginning of a survey so by placing the evaluation pages well into the survey, most people who are not motivated to complete the survey will drop out before reaching those pages. The inclusion of a page asking for demographic data before the evaluation pages also tends to ensure commitment and a facility to capture data in case of an early exit from the survey, ensuring that no data were lost. The survey operated satisfactorily on most Internet browsers. Figure 1 shows the layout of a questions page from the survey. Clicking on the image brings up a larger, higher-resolution image. This is repeated for each of the 30 images in each set.

Respondents were asked to answer three questions about each scene (Fig. 1). The question examining the respondent's perception of wilderness was: "Does this scene represent wilderness to you?" (yes/no). The question aimed at eliciting the respondent's perception of the aesthetic quality of the scene was: "Please select your preference rating on a scale of 1(low) to 7(high)". The question designed to investigate the suitability of a number of adjectives (semantic descriptors), which the respondent attached to each scene, was: "How well does each of the following words describe this scene?" (not at all, not well, neutral, well, very well).

There is no standard rating scale to choose from for aesthetic preference. Kaplan & Kaplan (1995) used a five-point scale for their preference studies; Roth (2006) used an 11-point scale for aesthetics (and other descriptive terms) and Sevenant & Antrop (2011) used a 10-point scale for beauty. In this study, we used a seven-point scale for aesthetic preference that was considered to provide sufficient resolution, giving the equivalent of three levels of like and dislike on either side of a neutral position.

Whether people generally think about wilderness as a binary concept or consider degrees of wilderness remains an open question. We sought a "yes/no" response for perceptions of wilderness, as opposed to a scaled response like that used for aesthetic preference, to test the hypothesis that it is the presence of infrastructure that degrades wilderness.

The semantic descriptors part of the survey asks respondents to assess the suitability of four words to describe the scene. To avoid survey fatigue, each respondent saw four words drawn randomly from the pool of 20 words so that the full set of 20 words (see Supplementary material) would be seen by five respondents. Each image—word combination was assessed by at least 20 respondents. Two words are from the lexicon of the beautiful, for example, "beautiful" and "lovely" and two words from the sublime, for example, "vast" and "grand." Analysis of the semantic descriptors part of the survey is reported in Summerson & Bishop (2011).

The survey was posted on a University of Melbourne website (currently http://people.eng.unimelb.edu.au/idbishop/Antarctica/) on 1 August 2009 following approval from the University of Melbourne Human Research Ethics Committee. Invitations to participate in the survey were sent to Antarctic research institutes in more than 10 countries, all 100 members of the International Association of Antarctic Tourism Operators, two environmental non-government organizations and many individuals. The survey was advertised on three Antarctic-related websites and "meta tags" were written into the home page to enable the survey to be picked up by Internet search engines.

Recognizing that many non-English-speaking countries have long histories of engagement with Antarctica, we

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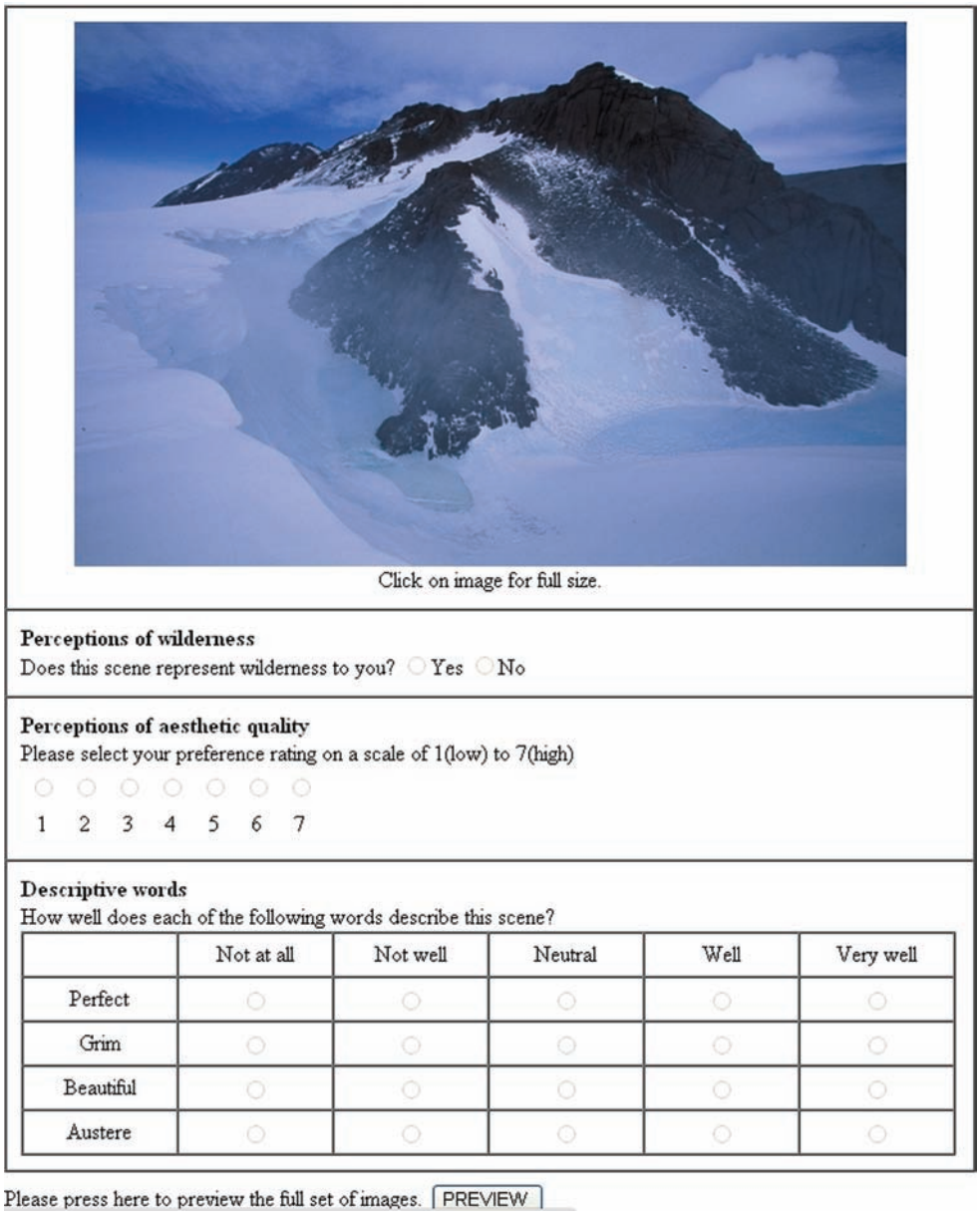

Fig. 1 Screen capture of the questions page of the online survey. (Photo by Frédérique Olivier.)

decided to extend the survey by translating it into other languages. Japanese was chosen as Japan was one of the original 12 signatories to the Antarctic Treaty and has remained a committed participant in Antarctica ever since. The Japanese version of the survey was launched on 29 January 2010. France was also an original signatory to the Antarctic Treaty; the French version of the survey was launched on 26 March 2010. Six Spanish-speaking countries are Antarctic Treaty Consultative Parties, two of which (Argentina and Chile) were original signatories; a Spanish version of the survey was launched on 23 May 2012. The results from the Spanish version are not included here. (The Japanese, French and Spanish versions of the online questionnaire have, respectively, the suffix jp, fr and es at the end of the address: http://people.eng.unimelb.edu.au/idbishop/Antarctica/.)

The 73 original images in the survey were selected by the first author (who has extensive personal experience of a wide range of Antarctic landscapes) to be representative of the following conditions: the absence of infrastructure or signs of transient human activity or the presence of infrastructure and/or transient human activity at different levels of intensity and at a range of levels of proximity, including a range of different types of infrastructure, such

as stations and field huts; six landscape types; and combinations of the above and in sufficient numbers to provide replicates for statistical validity.

Forty-five of the final images, that is, half of the images in the survey, included some form of, or evidence of, human activity, ranging from scenes of station areas to vehicle tracks. The images were obtained from a wide variety of sources, including institutional photographic libraries, individuals contacted through the Internet and personal collections. The distinction between infrastructure and transient activity is important. Infrastructure is defined as structures that are retained for long durations—years. Examples include Antarctic stations, field huts, marked airstrips and marked oversnow routes, including route markers. Transient activity is of a short duration and includes, for example, vehicles and people on foot, as well as evidence of their passing, such as tracks in the snow. For the purpose of this study, transient activity encompasses such things as a field camp used for a single field season or a mobile field party moving through an area (Fig. 3g). Activities that take place in the same locality over multiple seasons almost invariably require infrastructure. It was anticipated that respondents to the survey would react differently to infrastructure and transient activity and hypotheses were developed accordingly. The distribution of images across the landscape types and the human content of the images are listed in Table 1.

The Madrid Protocol calls for the protection of wilderness and aesthetic *values*. While this survey did not explicitly ask people to judge values directly, people were asked to express their aesthetic preferences and perceptions of wilderness. Most people use a relative preference scale rather than an absolute scale of aesthetic quality in their assessments (Kaplan & Kaplan 1995). There is an implicit valuation process in an expression of preference, if only, as Perry (1926) says, "Any object, whatever it be, acquires value when any interest, whatever it be, is taken in it" (p. 115). Hetherington et al. (1994) argue that values cannot be directly observed, whereas "preference-related value," "the setting by an individual of one thing before or above another thing because of a notion of betterness" is empirically measurable (p. 537).

Environmental regionalization

Annex V of the Madrid Protocol (Area Protection and Management) calls for the development of a "systematic environmental–geographical framework" within which to identify areas suitable for protection. Such a framework should include "representative examples of major terrestrial ... ecosystems" and "areas of outstanding aesthetic and wilderness value" (SAT 1991). In response to this requirement, the Environmental Domains of Antarctica (EDA) regionalization was developed by Landcare Research in New Zealand (Morgan et al. 2007). In Resolution 3 of the Thirty-first Antarctic Treaty Consultative meeting, the Committee for Environmental Protection recommended that "the 'Environmental Domains Analysis for the Antarctic Continent' ... be used consistently and in conjunction with other tools agreed within the Antarctic Treaty System as a dynamic model for the identification of areas that could be designated as Antarctic Specially Protected Areas" (SAT 2008).

However, the EDA has a number of limitations as a regionalization for human landscape perception research. First, many of the original bio-climatic environments are perceptually identical and are likely to evoke similar aesthetic responses. For example, there is little to distinguish Region N (East Antarctic inland ice sheet), Region O (West Antarctic ice sheet) and Region Q (East Antarctic high interior ice sheet) in terms of types of terrain (Fig. 2a). Second, where the visibility of regions overlaps, it is not clear which region is dominant. Third, there is no common region for coastal ice-free environments, which is where most Antarctic stations have been built (COMNAP 2012). To optimize the EDA for landscape perception research and wilderness and aesthetic values, the environments were reclassified into six regions or landscape types (Fig. 2b): central Antarctic ice sheet; coastal–continental margin; ice shelf and other floating glaciers; mountainous ice-free; Antarctic peninsula ice

Table 1 Number of scenes in each of the landscape types and the type of human activity in each. There is some overlap between images showing infrastructure and transient activity, for example, a photograph of vehicles parked near a field hut.

Landscape type/human content	Infrastructure	Transient activity	Total with human content	Total without human content	Total
Coastal ice-free	9	5	11	10	21
Mountainous ice-free	4	6	7	11	18
Ice shelves	3	4	6	6	12
Coastal–continental margin	4	6	8	7	12
Antarctic Peninsula ice fields	2	4	5	7	12
Central Antarctic ice sheet	5	7	8	4	12
Total	25	32	45	45	90

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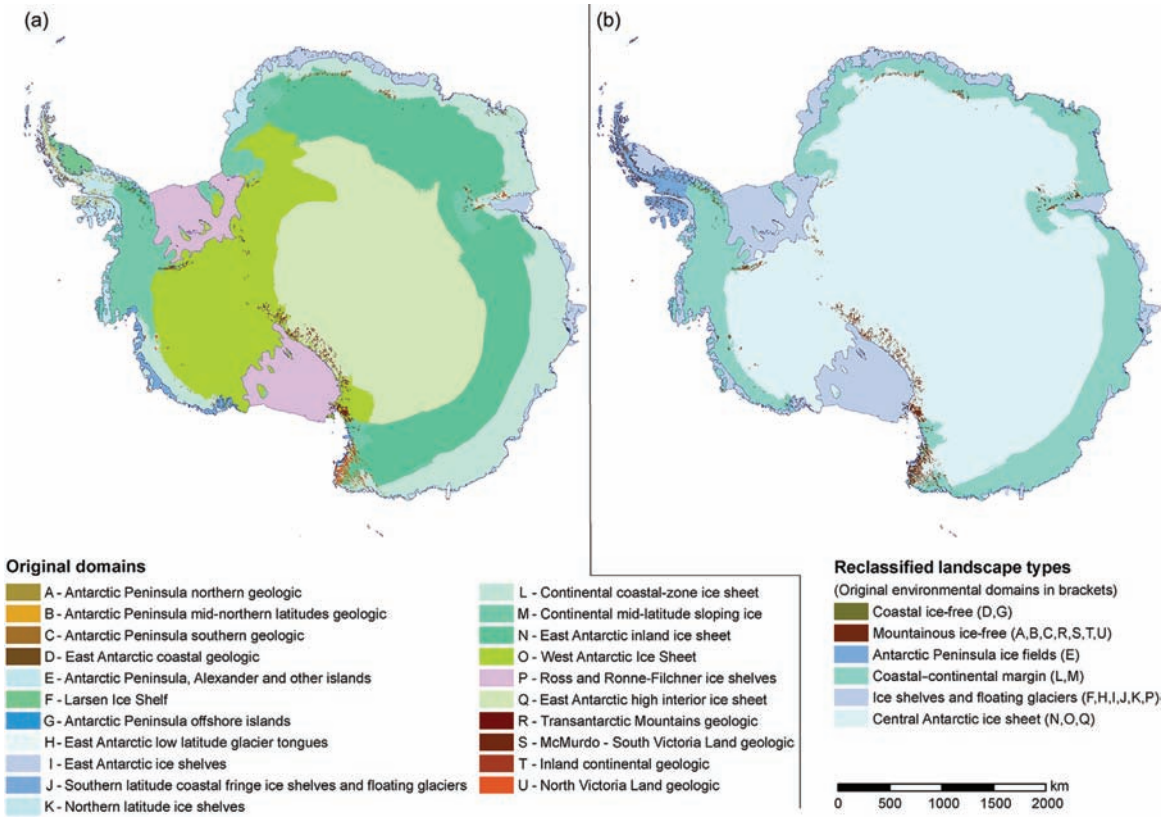

Fig. 2 (a) Original Environmental Domains of Antarctica and (b) the reclassified landscape types used in the analyses.

fields; and coastal ice-free. The logic of this reclassification is to group environments into regions that are, as far as possible, perceptually similar. The reclassified regions are termed "landscape types" to avoid confusion with the original EDA regions.

Included in the 90 images were 16 pairs in which infrastructure or human activity was removed by digital manipulation from one of the pairs, or in one case added to an otherwise natural scene. The manipulated pairs were randomly distributed throughout the survey with the manipulated image in one set of 30 images and the original in another set so that no respondent saw both the original and manipulated versions. The images in each pair were identical except for the human activity (infrastructure or transient activity), which was removed from one of the pairs and replaced with the best possible approximation of the natural environment. Since this is the only difference between each pair, any differences in ratings must be due to the presence/absence of infrastructure or transient activity. A complication in carrying out the digital manipulations was replacing the object removed with a realistic background. Since it was not possible to replace complex infrastructure, such as an Antarctic station in an ice-free area, with a natural background because of probable disturbance to the underlying terrain during station construction (Klein et al. 2008), it was decided not to attempt manipulation of such images.

One further image was digitally manipulated—a scene that included a large number of penguins. The penguins were digitally removed for a preliminary comparison of the effect of wildlife on aesthetic preference.

Digital manipulation was carried out using the GNU Image Manipulation Program, version 2.6.6 (GIMP 2009). Examples of the original and manipulated images are shown in Fig. 3.

Results

At the time of writing, 337 responses from 23 nationalities had been logged (Table 2). Among the respondents were 266 people who have experienced Antarctica and 71 people who have not. Of the people who have experienced Antarctica, 176 were scientists, science support personnel or operations personnel in national Antarctic research programmes. Respondents who have experienced Antarctica also included 74 tourists, 40 tourism industry staff (such as guides) and 19 participants

Fig. 3 Examples of original and digitally modified images. (a) Original image of a coastal ice-free scene (photo by Rupert Summerson) and (b) the modified image. (c) Original image of a mountainous ice-free scene (photo used with permission of the Australian Antarctic Division) and (d) the modified image. (e) Original image of an ice shelf (photo by John Penney, National Science Foundation Photo Library) and (f) the modified image. (g) Original image of an Antarctic Peninsula ice field (photo by Rupert Summerson) and (h) the modified image. (i) Original image of the central Antarctic ice sheet (photo by Brian Vasel, National Oceanic and Atmospheric Administration) and (j) the modified image.

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in private expeditions. Twenty-six respondents defined their experience in Antarctic as "other" or they did not specify it at all. Some respondents had some combinations of the above, for example, national Antarctic programme staff who had also visited Antarctica as tourists.

No attempt was made to determine how respondents heard about the survey. Seventeen of the 18 Japanese respondents took part in the Japanese version of the survey, whereas one respondent took part in the English version. Not all respondents completed all 30 scenes in a set, and the randomization algorithm used to allocate sets to respondents produced an uneven number of respondents per set, as shown in Table 3.

In total, 8778 individual evaluations of images were carried out, which gives a high degree of statistical power to the survey results. Each respondent viewed on average ca. 26 images.

The analyses of the results are described in two parts: impacts on perceptions of wilderness and impacts on perceptions of aesthetic quality. Analyses were carried out using PASW (now SPSS) Statistics 18 (http://www.ibm.com/spss).

Impacts on perceptions of wilderness

All images. A chi-square test for independence (with Yates continuity correction) was carried out on all assessments to test the effect of human presence on wilderness. As noted above, half of the images in the survey included evidence of human presence. A significant association was found between human presence and ratings of "not wilderness": χ^2 $(1,\ n=8731) = 677.78$, $p=0.000$, $\Phi=-0.279$. Effect size, a measurement of the absolute magnitude of a treatment effect independent of the size of the sample being used, was calculated using the Φ coefficient (Gravetter & Wallnau 2010). A value of 0.1 is a small effect, 0.3 a moderate effect and 0.5 a large effect (Cohen 1988). However, there is more complexity than these figures might suggest. There is considerable variability in assessments of "wilderness" within the set of 45 images containing human presence, from under 15% of responses for an image of an Antarctic station to over 97% for an image with a field hut in the distance (Fig. 4). Figure 4 is a breakdown of the type of human content in the images but does not include categorization of proximity. By contrast, there is very little variety in the set of 45 images without human presence (Fig. 4). Assessments of "wilderness," that is, the scene represents wilderness, range from 82% of responses to 100%, with over 64% of images having >95% assessments of "wilderness."

Table 2 Number of survey participants from different nations and regions.

Nationality	Count
Australia	146
UK	58
USA	47
Japan	18
New Zealand	16
Canada	9
Other European countries	21
South America	11
Others	4
Not specified	7

Table 3 Maximum number of respondents in each set of images.

Set 1 (images 101–130)	Set 2 (images 201–230)	Set 3 (images 301–330)
94	125	118

Images aggregated by landscape type. To test the effects of different landscape types on perceptions of "wilderness" and "not-wilderness," assessments of wilderness were analysed by landscape type. Percentages of assessments of wilderness for each landscape type are shown in Fig. 5. The type of human presence is undifferentiated.

Chi-square tests were carried out to compare assessments of "wilderness" and "not-wilderness" in each landscape type to determine whether human presence has a significant effect. Tests were carried out on all images and then, separately, on images containing infrastructure (complex and minor combined) and images showing transient activity. Comparisons were made with all images with no human presence from that landscape type. Images that showed both infrastructure and transient activity were treated as infrastructure. The results are shown in Table 4.

Manipulated pairs. Figure 6 shows the percentages of assessments of wilderness, that is, the percentage of assessments of wilderness as a proportion of the total number of assessments of both the manipulated images, which were perceived as being natural, and assessments of their counterpart unmodified images. The latter included some form of human presence, either infrastructure or transient activity. In all cases, the percentage ratings of wilderness of the images with human presence were lower than those of their counterpart images that were apparently natural. Eleven of the image pairs included scenes of infrastructure and of these the differences between pairs of nine images were judged to

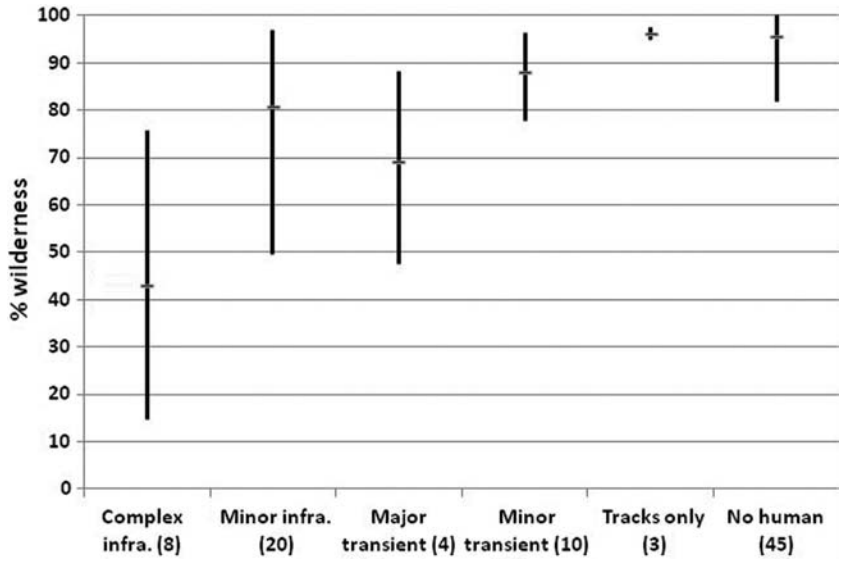

Fig. 4 Ranges of assessments of ''wilderness'' among images with human content, grouped by human content type. ''Complex infrastructure'' is defined as multiple buildings and structures, for example, stations. ''Minor infrastructure'' is one or two buildings and/or structures, for example, field huts. ''Major transient'' is defined as ships, aircraft or heavy vehicles. ''Minor transient'' is light vehicles or people on foot. ''Tracks only'' are tracks in snow only. The figures in brackets are the numbers of images in each group. The vertical bars represent the range of assessments in each group: minimum to maximum; the mean is represented by the cross-bar. The range of assessments of ''wilderness'' of the 45 images *without* human content is shown on the right for comparison.

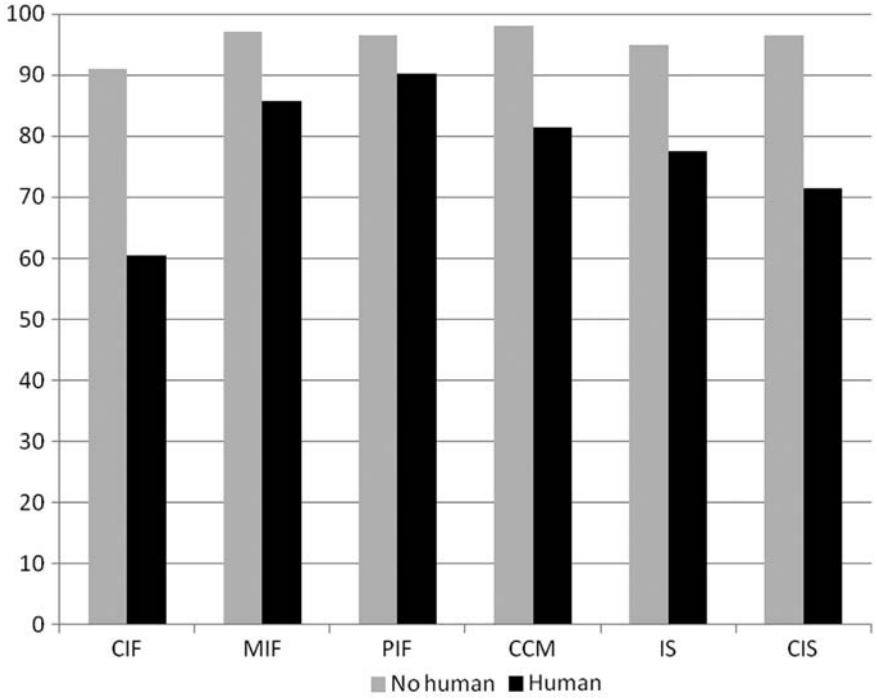

Fig. 5 Percentage assessments of wilderness: all images with and without human presence aggregated by landscape type. The black columns are the percentages of responses perceived as wilderness of all images *with* human presence. The grey columns are the percentages of assessments of wilderness of all images in each landscape type *without* human presence. Landscape types are abbreviated as follows: coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).

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Table 4 Results of Pearson's chi-square tests with Yates's continuity correction (χ^2) comparing assessments of wilderness and not-wilderness between all images aggregated by landscape type, differentiated by all images, images containing infrastructure and images containing transient activity. Significance (p) and effect size (Φ) are shown.

	All			Infrastructure			Transient activity		
Landscape type[a]	χ^2	p	Φ	χ^2	p	Φ	χ^2	p	Φ
CIF	251.75	0.00	0.35	330.89	0.00	0.43	0.23	0.63	0.02
MIF	76.55	0.00	0.21	97.93	0.00	0.26	20.91	0.00	0.13
PIF	20.63	0.00	0.13	10.56	0.00	0.11	17.41	0.00	0.13
CCM	85.36	0.00	0.25	59.46	0.00	0.25	95.03	0.00	0.32
IS	81.82	0.00	0.25	161.74	0.00	0.41	2.93	0.09	0.06
CIS	79.93	0.00	0.28	105.29	0.00	0.39	41.24	0.00	0.25

[a]Coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).

be statistically significant ($\alpha = 0.05$, $p < 0.05$). Of the five pairs of images which included transient activity, the differences between three pairs were significant. It is notable that the percentage assessments of wilderness of the apparently natural images of coastal ice-free areas are generally lower than images from other landscape type. This is consistent with the findings from the semantic assessment of the survey (Summerson & Bishop 2011).

Chi-square tests were carried out on the 16 pairs of images that had been digitally manipulated (see Fig. 3 for examples); the results are shown in Table 5.

One other pair of images was manipulated: penguins were digitally removed from an image as a preliminary test of the impact of wildlife on assessments of wilderness. Ninety-nine percent of responses to the original scene with penguins indicated that it represented wilderness, whereas of the responses to the manipulated image from which the penguins had been removed, 94% of responses were that it represented wilderness—a non-significant difference. This is confirmed by the Fisher's Exact test which showed a non-significant difference (Table 5).

Impacts on perceptions of aesthetic value

To correct for scaling differences between respondents, a problem inherent in raw ordinal aesthetic preference scores (Daniel & Boster 1976), the responses were first converted to Z scores: Z = (respondent's image

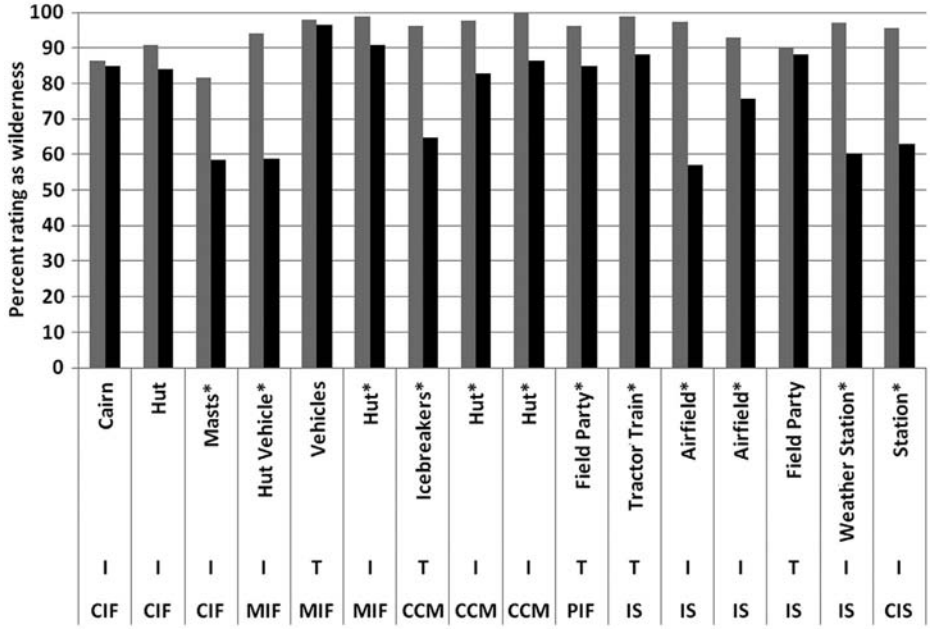

Fig. 6 Percentages of assessments of wilderness for each image pair in the 16 pairs of images. Landscape types are abbreviated as follows: coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS). The type of human presence in the original images is either infrastructure (I) or transient activity (T). The black column represents values for images with human presence, and the grey column to images without human presence. Significant difference is indicated with asterisks.

Table 5 Results of chi-square tests of responses on perceptions of wilderness of the 17 pairs of digitally manipulated pairs of images. Italicized significance (*p*) values are results from Fisher's Exact Test, used in place of χ^2 owing to frequencies <5 in cells in contingency tables.

No.	Landscape type[a]	Subject	Infrastructure (I)/ transient activity (T)	N^b_{human}	$N^c_{natural}$	χ^{2d}	*p*	Φ^e
1	CIF	Cairn	I	79	96	0.009	0.926	−0.02
2	CIF	Radio masts	I	101	115	13.05	0	−0.26
3	CIF	Field hut 1	I	81	98	1.35	0.24	−0.1
4	MIF	Field hut 2	I	110	80	–	*0.027*	−0.17
5	MIF	Field hut/vehicle	I	104	101	33.39	0	−0.41
6	MIF	Vehicles	T	112	100	–	*0.69*	−0.05
7	CCM	Icebreakers	T	113	78	24.56	0	−0.37
8	CCM	Field hut 3	I	99	81	8.7	0.003	−0.24
9	CCM	Field hut 4	I	111	102	12.84	0	−0.26
10	PIF	Field party 1	T	100	80	5.063	0.024	−0.19
11	IS	Tractor train	T	101	79	5.955	0.015	−0.2
12	IS	Airfield 1	I	98	80	36.41	0	−0.46
13	IS	Airfield 2	I	78	115	10.3	0.001	−0.25
14	IS	Field party 2	T	77	109	0.011	0.916	−0.02
15	IS	Automatic weather station	I	113	98	38.3	0	−0.44
16	CIS	Station	I	100	112	33.19	0	−0.41
No.	Landscape type	Subject	Infrastructure / transient activity	$N_{penguins}$[f]	$N_{0\_penguins}$[g]	$\chi^{2\ d}$	Significance	Effect size
17	PIF	Penguins	–	99	111	–	*0.07*	0.14

[a]Coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).
[b]N_{human} is the sample size of images with human presence.
[c]$N_{natural}$ is the sample size images without human presence.
[d]Results of Pearson's chi-square tests with Yates's continuity correction (χ^2).
[e]Effect size. The sign of the phi coefficient (Φ) is immaterial.
[f]$N_{penguins}$ is the sample size of images with penguins.
[g]$N_{o\_penguins}$ is the sample size images without penguins.

score − mean of all respondent's scores)/standard deviation of all respondent's scores). The resulting Z scores were then treated as interval data as a number of authors (e.g., Arriaza et al. 2004) have reported that there is little error in treating ordinal aesthetic preference data as interval data. Effect size was calculated using Cohen's *d*: the mean difference divided by the standard deviation (Cohen 1988), where 0.2 is a small effect, 0.5 is a moderate effect and 0.8 is a large effect. Raw aesthetic preference data were acquired on a scale of 1 to 7; when converted to Z scores, the scale of responses was from −5.13 to 2.56 (Fig. 7).

All images. An independent samples *t*-test was carried out on the Z scores of all responses to compare aesthetic responses to images with some form of human presence to those without any evidence of human presence. The difference between the scores was significant and as follows. Images with human presence had a mean of −0.328, SD = 1.05; while natural images had a mean of 0.33, SD = 0.77; *t* (df = 8043) 33.29, $p = 0.00$, two-tailed. The magnitude of the differences in the means (mean difference = 0.659, 95% confidence interval [CI]: 0.620 to 0.697) was moderate (Cohen's $d = 0.71$). Independent samples *t*-tests were also carried out between all images with no human presence (natural images) and, separately, images containing transient activity or evidence of transient activity, that is, tracks in the snow and images containing infrastructure. The differences between the scores of both transient activity and infrastructure and images with no human presence were significant and as follows. Images with transient activity had a mean of −0.053, SD = 0.905; while natural images had a mean of 0.33, SD = 0.77; *t* (df = 3042) 15.85, $p = 0.00$, two-tailed. The magnitude of the differences in the means (mean difference = 0.383, 95% CI: 0.336–0.431) was small to moderate (Cohen's $d = 0.47$). Images with infrastructure had a mean of −0.529, SD = 1.102; while natural images had a mean of 0.33, SD = 0.77; *t* (df = 4007) 34.53, $p = 0.00$, two-tailed. The magnitude of the differences in the means (mean difference = 0.859, 95% CI: 0.811–0.908) was large (Cohen's $d = 0.94$).

Landscape types. The mean aesthetic (Z) scores of all natural scenes and scenes with human content, differentiated by whether it is transient or infrastructure

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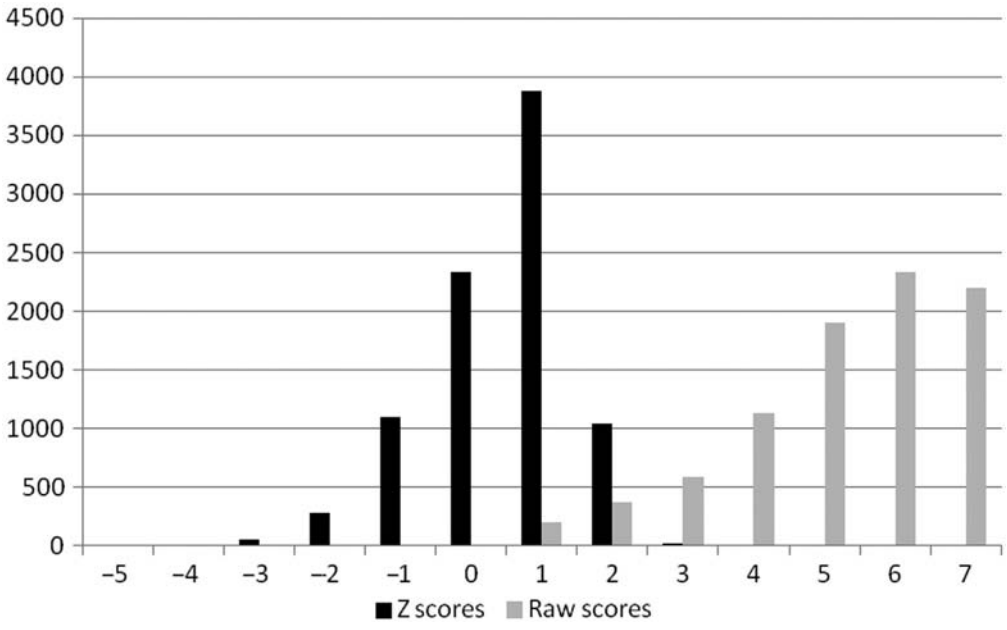

Fig. 7 Frequency plot of Z scores and raw aesthetic preference ratings for all images in the survey.

and aggregated by landscape type, is shown in Fig. 8. It can be seen that, first, mean aesthetic scores of the coastal ice-free landscape type are substantially lower than all the other landscape types, which, second, have similar mean scores, and third, the mean scores of images with human content are demonstrably lower than images of natural scenes.

Independent samples *t*-tests were carried out on the Z scores of all images in each of the six landscape types, comparing images of natural scenes with images of human presence divided into transient activity and infrastructure (Tables 6, 7). The human content is divided into transient activity and infrastructure. In addition to the *t*-tests, 95% confidence limits for the means and effect

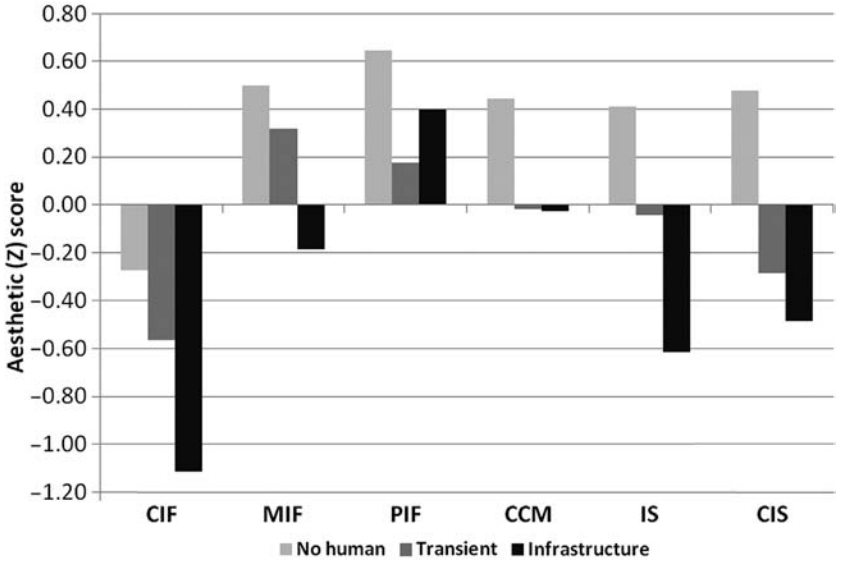

Fig. 8 Mean aesthetic (Z) scores of images, with human content, transient activity and infrastructure, aggregated by landscape type. Landscape types are abbreviated as follows: coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).

Table 6 Aesthetic (Z) scores for landscape types, with *t*-test results comparing images with no human content and images with transient human activity.

Landscape type[a]	Human content	N	Mean Z score	SD	*t*	Df[b]	*p* (two-tailed)[c]	Mean difference[d]	95% confidence interval (lower)[e]	95% confidence interval (upper)[e]	Φ[f]
CIF	Yes	214	−0.562	0.791	4.794	1184	0.000	0.287	0.169	0.404	0.36
	No	972	−0.275	0.792							
MIF	Yes	303	0.317	0.665	3.977	1323	0.000	0.183	0.093	0.273	0.26
	No	1022	0.5	0.715							
PIF	Yes	284	0.174	0.757	9.453	422	0.000	0.472	0.373	0.569	0.72
	No	799	0.645	0.613							
CCM	Yes	390	−0.018	0.965	8.213	637	0.000	0.462	0.352	0.573	0.58
	No	551	0.444	0.656							
IS	Yes	291	−0.042	0.773	8.664	486	0.000	0.452	0.349	0.554	0.64
	No	694	0.41	0.68							
CIS	Yes	359	−0.287	1.073	11.033	625	0.000	0.767	0.63	0.903	0.83
	No	306	0.48	0.705							

[a]Coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).
[b]Degrees of freedom.
[c]Significance ($\alpha = 0.05$).
[d]The mean difference between each pair of images.
[e]Upper and lower confidence intervals around the mean differences.
[f]Effect size.

sizes were also calculated. Effect size was calculated using pooled standard deviation.

Manipulated pairs. Independent samples *t*-tests were carried out on aesthetic ratings (Z scores) of the 17 pairs of digitally manipulated images. The results, grouped by landscape type and indicating whether the scene is of infrastructure or transient activity, are shown in Table 8. The small differences in the numbers of respondents between Table 8 and Table 5 are due to some respondents not responding to all 30 images. The differences in the means between the original images, with human presence, and the manipulated images, which respondents perceive as being natural, are mostly negative because the mean values of the images with human presence are mostly lower than the mean values of the images which are perceived as natural. This indicates that scenes with human presence generally have lower aesthetic value than natural scenes. However, in one case, the presence of a cairn appears to have enhanced the aesthetic rating of the image (Fig. 3a).

Table 7 Aesthetic (Z) scores for landscape types, with *t*-test results comparing images containing no human content and images with infrastructure.

Landscape type[a]	Human content	*N*	Mean Z score	SD	*t*-test	df[b]	*p* (two-tailed)[c]	Mean difference[d]	95% confidence interval (lower)[e]	95% confidence interval (upper)[e]	Φ[f]
CIF	Yes	857	−1.114	1.13	18.139	1509	0.000	0.839	0.748	0.929	0.87
	No	972	−0.275	0.79							
MIF	Yes	416	−0.187	0.851	14.516	665	0.000	0.687	0.594	0.78	0.91
	No	1022	0.5	0.715							
PIF	Yes	180	0.398	0.654	4.63	255	0.000	0.247	0.142	0.352	0.4
	No	799	0.646	0.613							
CCM	Yes	400	−0.026	0.8	9.642	753	0.000	0.47	0.375	0.566	0.65
	No	551	0.444	0.656							
IS	Yes	290	−0.616	1.02	15.72	400	0.000	1.025	0.897	1.154	1.29
	No	694	0.41	0.678							
CIS	Yes	386	−0.486	1.072	14.242	669	0.000	0.966	0.833	1.099	1.04
	No	306	0.48	0.705							

[a]Coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).
[b]Degrees of freedom.
[c]Significance ($\alpha = 0.05$).
[d]The mean difference between each pair of images.
[e]Upper and lower confidence intervals around the mean differences.
[f]Effect size.

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Table 8 Mean differences between the aesthetic (Z) scores of images with human presence and ''natural'' (manipulated) images.

Pr.	Content	Infrastructure (I)/ transient activity (T)	Landscape type[a]	N/p[b]	N/n[c]	*t*-test	*p*[d]	Mean diff.[e]	95% confidence interval (lower)[f]	95% confidence interval (upper)[f]	*d*[g]
1	Cairn	I	CIF	79	96	2.24	0.026	0.28	0.03	0.52	0.34
2	Radio masts	I	CIF	101	115	−2.48	0.014	−0.24	−0.43	−0.05	−0.34
3	Field hut 1	I	CIF	81	98	−2.28	0.021	−0.24	−0.44	−0.03	−0.34
4	Field hut 2	I	MIF	109	79	−3.86	0.000	−0.31	−0.47	−0.15	−0.55
5	Field hut/vehicle	I	MIF	104	101	−5.52	0.000	−0.6	−0.81	−0.38	−0.77
6	Vehicles	T	MIF	112	100	−4.37	0.000	−0.32	−0.46	−0.17	−0.6
7	Icebreakers	T	CCM	113	77	−8.18	0.000	−0.92	−1.14	−0.7	−1.09
8	Field hut 3	I	CCM	99	80	−2.33	0.024	−0.22	−0.41	−0.03	−0.35
9	Field hut 4	I	CCM	111	102	−5.15	0.000	−0.52	−0.72	−0.32	−0.71
10	Field party 1	T	PIF	99	77	−1.54	**0.126**	−0.126	−0.37	0.05	−0.23
11	Tractor train	T	IS	102	79	−2.59	0.010	−0.26	−0.46	−0.06	−0.39
12	Airfield 1	I	IS	99	78	−9.69	0.000	−1.1	−1.33	−0.88	−1.37
13	Airfield 2	I	IS	78	115	−6.67	0.000	−0.87	−1.13	−0.61	−1.06
14	Field party 2	T	IS	77	109	−0.92	**0.360**	−0.1	−0.32	0.12	−0.14
15	Automatic weather station	I	IS	113	98	−13.2	0.000	−1.4	−1.61	−1.19	−1.79
16	Station	I	CIS	99	112	−7.32	0.000	−0.87	−1.11	−0.64	−1.04
17	Penguins	–	PIF	98	110	−4.35	0.00	−0.36	−0.52	−0.2	0.61

[a]Coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).
[b]The number of respondents to images with penguins (pair 17).
[c]The number of respondents to the natural (manipulated) images.
[d]Significance ($\alpha = 0.05$). Figures in boldface are non-significant results.
[e]The mean difference between each pair of images.
[f]Upper and lower confidence intervals around the mean differences.
[g]*d* is Cohen's *d*, for which 0.2 is a small effect, 0.5 is a moderate effect and 0.8 is a large effect.

The differences in the means in all manipulated pairs, with two exceptions are significant. Effect sizes (Cohen's *d*) are also shown.

An independent samples *t*-test to compare the aesthetic ratings (Z scores) of the manipulated images with the penguins was also carried out. There was a significant difference between scores for the image with penguins (mean = 0.80, SD = 0.641) and without penguins (mean = 0.44, SD = 0.549; t (206) = −4.35, $p = 0.000$, two-tailed). The image with penguins was significantly preferred over the image without. The effect size was 0.61 which is a moderate effect.

Discussion

Wilderness and aesthetic values have been treated as separate sets of values throughout this article; the results will therefore be discussed separately. However, it was found that human presence has similar effects on each value. The implications of this are also discussed.

Two research questions relating to wilderness were proposed at the beginning of this article: (1) What is wilderness in the Antarctic context—and therefore what area or areas can be designated as wilderness? (2) How can human impacts on wilderness values be defined and measured?

The proposition was made that all Antarctica is wilderness unless it has been degraded by human activity. It was proposed further that degradation occurs with the construction of infrastructure rather than with transient activity and that if infrastructure is visible, then the area from which it is visible would be perceived as being no longer wilderness. A simple, practical approach to implementing protection of wilderness values would therefore be to calculate the visibility footprint of infrastructure using the standard routines available in most geographical information systems, as outlined in Summerson (2012), and designate areas outside the visibility footprint as wilderness.

As noted above, there is considerable variety in the assessment of wilderness among the 45 images with human content. To a large extent, this can be explained by the type of human content as certain types of human presence were assessed as having a greater impact on wilderness than others (Fig. 4). The lowest assessments of wilderness were given to complex infrastructure, such as stations and associated infrastructure, and to large-scale transient activity, such as ships and aircraft. Images of minor transient activity, such as small field parties, and evidence of recent transient activity were generally assessed as having less impact on wilderness (Fig. 4). The effect of proximity was not taken into account and will be the subject of future research.

The differing assessments of wilderness between images with and without human content when aggregated by landscape type (Fig. 5) are likely to be a consequence of the type of human content in the images. As described in Table 1, there are unequal proportions of imagery with and without human content across the six landscape types. Attempts to standardize the assessment of wilderness across landscape types by taking into account the number of images with human content and type of human content have not been conclusive.

It is notable that the coastal ice-free landscape type was generally assessed as having less wilderness value than other regions (Fig. 5). The generally lower value ascribed to this region was noted by Summerson & Bishop (2011) in the semantic descriptors part of the survey.

The manipulated pairs component of the survey provides the maximum details on how people react to human presence (Fig. 6). Twelve of the manipulated pairs were judged as having a significant difference in perceptions of wilderness between the original image (with human content) and its manipulated, apparently natural, counterpart. Four pairs were judged not to be significantly different. Examples of the type of human presence and whether or not the chi-square tests for independence were significant are summarized in Fig. 9.

There are eight images containing field huts in the survey, five of which form part of the manipulated pairs set. Percentage assessments of wilderness of all the field huts range from 59% to 97%. Although the differences between the original images showing field huts and the "natural" images, from which the field huts had been removed, were significant in all but one case, the lowest percentage rating of wilderness was 59%. As a point of comparison, the image with the lowest percentage rating of wilderness, a scene of a coastal Antarctic station, scored 14.7%.

There is a consistent effect in all three groups of tests (all images combined, images grouped by landscape type and manipulated pairs) of human presence depressing the assessment of wilderness.

Whether the binary approach to defining wilderness adopted in this study—i.e., the "yes" or "no" response requested—provides sufficient discrimination between the types of human impact on Antarctic landscapes or whether grades of wilderness (e.g., Lesslie & Taylor 1985) are more appropriate, we anticipate will be reviewed as part of ongoing policy development. Differences among individuals as to what constitutes wilderness could be used to define grades of wilderness, if that is useful in policy setting.

Similar research questions were asked about aesthetic values: (1) What are aesthetic values in the Antarctic context? (2) How can human impacts on aesthetic values be defined and measured? The results of the survey show that, among natural landscapes, there is considerable difference in aesthetic preferences between the coastal ice-free landscape type and the other landscape types (Fig. 10). The lower aesthetic preferences ascribed to this region are consistent with the lower wilderness ratings described above and the different semantic evaluations as noted by Summerson & Bishop (2011). Within the other landscape types, there is a general preference for mountainous scenes (mountainous ice-free and peninsula ice fields landscape types). The 95% confidence limits are at

Fig. 9 Examples of the types of infrastructure and transient activity and significance in differences in wilderness scores in the manipulated pairs. Only the non-manipulated images are shown. (Photos: Australian Antarctic Division, Ewan McIvor, Rupert Summerson and—courtesy of the US National Science Foundation Antarctic Photo Library—Kristan Hutchison, John Penney and Jordan Dickens.)

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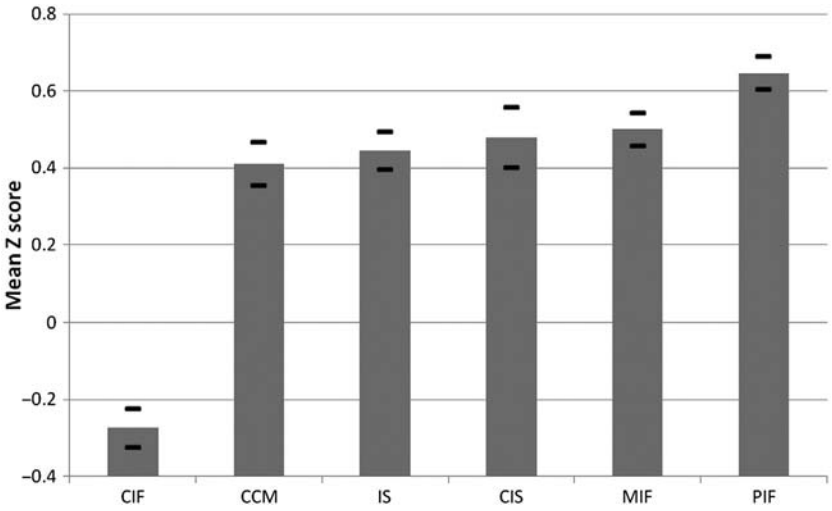

Fig. 10 Aesthetic Z scores for all images without human content, averaged by landscape type. The horizontal bars represent 95% confidence intervals. Landscape types are abbreviated as follows: coastal ice-free (CIF), mountainous ice-free (MIF), coastal–continental margin (CCM), peninsula ice fields (PIF), ice shelves (IS) and central Antarctic ice sheet (CIS).

a similar level in all regions, which is consistent with the lower standard deviations observed for natural scenes in comparison with scenes with infrastructure (Table 7) but not exclusively in scenes with transient activity (Table 6).

It is notable that the three most preferred images are of mountains and the three least preferred are of coastal ice-free regions (Fig. 11). Many authors have commented on the attraction of mountains, at least since the 18th century (Nicolson 1963). Indeed, the love of mountain scenery has become such a commonplace that Carlson commented (about a landscape preference model) that:

> the model works in such a way as to tell us only the obvious, that is, it predicts what we already know … that the public prefers the kind of landscape scenes so common on postcards, calendars and popular landscape paintings—usually mountains and water with an occasional waterfall …. (Carlson 1977: 146)

Many authors (e.g., Kaplan & Kaplan 1995; Wu et al. 2006) have commented on the preference for natural scenes—without human content—so it is not surprising that wilderness and landscape aesthetics are similarly valued.

Impacts on aesthetic value followed a similar pattern to impacts on perceptions of wilderness, with some exceptions. The peninsula ice fields landscape type, for example, includes three images with transient activity and two with infrastructure (Fig. 8); the infrastructure is distant and indistinct by comparison with the images of transient activity.

As described above, the assumption was made that wilderness and aesthetic values are separate sets of values. Nevertheless, Fig. 12 shows that there is a relationship between perception of wilderness and aesthetic preference.

The relationship is strongest among the images that include infrastructure (Fig. 12). This is confirmed with an analysis using the Pearson product–moment correlation coefficient. There was a strong positive correlation between average aesthetic rating (Z score) and percentage of responses of wilderness to each image ($r = 0.918$, $n = 26$, $p < 0.0005$). The relationships between these two variables among images with transient activity and images without human presence were also investigated using the same technique. The values for images with transient activity were: $r = 0.680$, $n = 19$ and $p = 0.001$, while the values for images lacking in signs of human presence were: $r = 0.640$, $n = 45$ and $p < 0.0005$. Therefore, it is clear that human presence, or evidence thereof, in the images has a negative impact on both perceptions of wilderness and aesthetic preference and this effect is strongest in images which include infrastructure. The images with the lowest ratings of both wilderness and aesthetic value among the set that included infrastructure and the set without human presence were from the coastal ice-free region, whereas the lowest rated images in the transient activity set were of heavy transport activity (ice-breakers and a low flying Hercules aircraft). Therefore, it seems that in addition to human presence, the landscape type is a further factor in the relationship between wilderness and aesthetic preference. How this relationship is formed in people's minds

Fig. 11 (a–c) The three most aesthetically preferred and (d–f) the three least aesthetically preferred natural scenes, that is, without human presence. (Photos: [a] Paul Thur; [b] Zee Evans; [c] Frédérique Olivier; [d] Rupert Summerson; [e] and [f] Ewan McIvor. Photos [a], [b] and [f] courtesy of the US National Science Foundation Antarctic Photo Library.)

and what it represents is an open question and needs more research.

Conclusions

It is clear from the results that people were found to value landscapes that they saw as undisturbed. The scenes with the lowest aesthetic preference ratings, and those that are considered least like wilderness, are views of stations and associated permanent infrastructure. Transient activity, depending on scale and intensity, may also result in perceived loss of wilderness and reduction in aesthetic preference although minor levels seem to be tolerated. It is also clear that not all natural landscapes are equally aesthetically preferred, for example, scenes in the coastal ice-free landscape type are generally less preferred than other landscape types; this will be the subject of future research. The similarity in the impacts of human activity and infrastructure on wilderness and aesthetic preference ratings suggest that wilderness and aesthetic values are related in peoples' minds; this will also be the subject of further research. The proposition that all Antarctica can be defined as wilderness unless it has been degraded by human activity still holds.

The recommended application of this research to the implementation of the Madrid Protocol is as follows. It is possible and feasible to identify both wilderness and aesthetic value in Antarctic landscapes with a high degree

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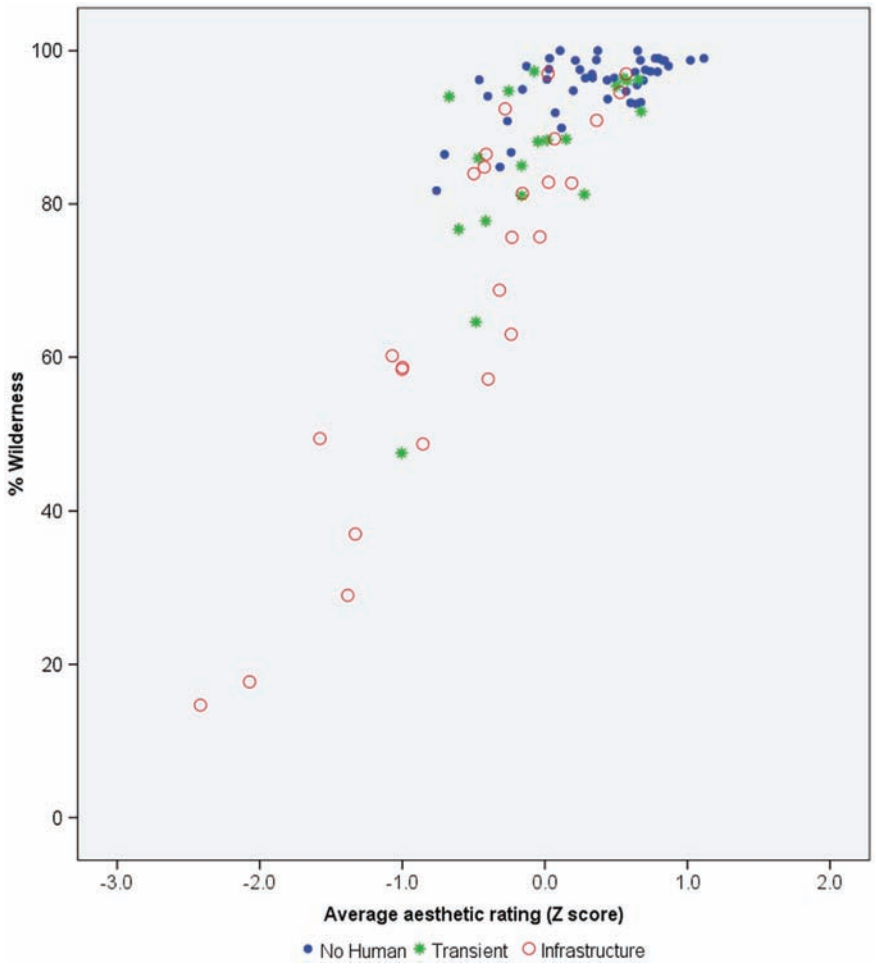

Fig. 12 Scatter plot of averaged responses to wilderness and aesthetic value of all 90 images. Perception of wilderness is expressed as a percentage of responses as wilderness to each image and aesthetic values as mean Z scores.

of confidence. It has been demonstrated that infrastructure impacts negatively both wilderness and aesthetic values, so environmental impact assessments for proposed new infrastructure must take this into account to avoid such impacts. In terms of protected areas, the recognition that the default condition of Antarctica is wilderness would obviate the need to establish protected areas for wilderness; however, the corollary is that human activities would need to be managed to avoid unnecessary expansion of infrastructure into areas that are currently wilderness, especially in coastal ice-free areas. Implementation of protection of areas for their aesthetic values would possibly proceed best with a test case to identify the management issues, which are likely to be different to the issues in areas designated to protect fauna or flora. It would, for example, be illogical to exclude people from areas with high aesthetic value, but, as the results of the survey have demonstrated, infrastructure must be excluded.

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