

Protection of the Wilderness and Aesthetic Values of Antarctica: Geographical Information Systems (GIS) as a Tool

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Abstract—Antarctica is designated by the Antarctic Treaty System as a “natural reserve devoted to peace and science” (http://www.ats.aq/index_e.htm). Multiple, and sometimes conflicting, values are protected. In a place where wilderness protection and certain forms of human activity are both prized, a discussion of the protection of the Antarctic wilderness necessarily leads to the question of the present and future human footprint in Antarctica. A comprehensive and systematic assessment of the human footprint in Antarctica has never been done, and in this paper the authors explore the opportunities and challenges in conducting such an assessment. On examining the exchange of information conducted under the Antarctic Treaty System, one finds that the information on human activity in Antarctica is relatively centralized, and that with the right permissions, together with dedicated and significant effort, it should be possible to assemble all information in one place. After that, the next challenge lies in the representation of this data in a coherent manner that would be useful for planning purposes. Geographical Information Systems (GIS) are a useful tool for representing this data; however, much work still needs to be done to arrive at a system that is clear, transparent, and reproducible and can illustrate the impacts of human activities on wilderness character or values.

collectively by 28 countries under the Antarctic Treaty System (ATS), which designates Antarctica as a “natural reserve devoted to peace and science” (http://www.ats.aq/index_e.htm). Its environment and ecosystems are protected under the terms of the Protocol on Environmental Protection to the Antarctic Treaty (the “Madrid Protocol”) which was ratified in 1998, and so is its intrinsic value, “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” (http://www.antarctica.ac.uk/about_antarctica/geopolitical/treaty/update_1991.php). Thus, multiple, and sometimes conflicting, values are protected, and thus far, there has not been any explicit articulation of the hierarchy of these values. Historically and conventionally, though, science has taken precedence over all other human activities. In a place where wilderness protection and certain forms of human activity are both prized, a discussion of the protection of the Antarctic wilderness necessarily leads to the question of the present and future human footprint in Antarctica. Perhaps a bit surprisingly, a comprehensive and systematic assessment of the human footprint in Antarctica has never been done. In the following sections, we consider the opportunities and challenges in conducting such an assessment.

Introduction

Antarctica is the biggest and most intact terrestrial wilderness left on Earth. However, like the rest of the world, increasing globalization, mobility, and search for commercial gains are putting pressure on even this, the most remote of all continents (Tin and others 2008). Antarctica is managed

Assessing the Current Human Footprint in Antarctica

Defining the Footprint

Infrastructure (buildings and structures) and activity (people doing things or in transit) are the two major components of a human footprint. Infrastructure often has a lifetime of many years. The establishment of infrastructure almost invariably results in major long-term impacts on the visible landscape, such as tracks established around buildings, building footings and anchor points, the establishment of pipelines and cables, spillage of hydrocarbons, sewage outfalls, etc. Even when infrastructure is removed, there will inevitably be a legacy, sometimes in terms of visible elements, others in terms of chemical traces that are not necessarily readily detectable, such as spillage of hydrocarbons and discharge of sewage.

Activity, by contrast, is transient. A scientific field party moving through an area may leave no trace apart from vehicle tracks in the snow. Where scientific research has

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been conducted, there may be the minor scarring, such as where rock samples have been taken. An aircraft flying from A to B is an activity, though an established route with regular scheduled flights could be considered infrastructure. In terms of representing infrastructure and activity on a map, all have to be represented with symbols that make it difficult to separate them in the mind of the user. Once the location and type of infrastructure have been compiled and the distribution and intensity of activity established, it will be possible to define the footprint accurately.

Data Acquisition

Human activities on the Antarctic continent and in the Southern Ocean falls under three broad categories: (1) scientific research and its associated logistics run by national Antarctic programs of Parties to the Antarctic Treaty; (2) tourism activities; and (3) commercial fishing. Tourism and commercial fishing are both organized by commercial entities. The majority of human activities take place during the austral summer, from November to February. Scientific research and its associated logistics is the only activity that takes place year-round, though most activity also takes place during the austral summer.

Scientific Research and Its Associated Logistics—Ever since the first Antarctic Treaty Consultative Meeting in 1961, there have been numerous measures and resolutions to promote the exchange of scientific and logistical information among Treaty Parties, i.e., those countries that have acceded to the Antarctic Treaty. The Council of National Antarctic Programs (COMNAP) maintains a list of the facilities being operated by national Antarctic programs (<https://www.comnap.aq/facilities>). These include active and a few disused research stations and seasonal (summer) facilities. In 2008, the Electronic Information Exchange System on the Antarctic Treaty Secretariat's website began operation, providing a central location for the operational and logistical information of all 28 Antarctic Treaty Parties (<http://www.ats.aq/e/ie.htm>). Prior to each season, Parties submit information on the stations that they will be using, the ships that will be going to Antarctica, the numbers of voyages and areas of operation of each ship, as well as types of aircraft, planned number of flights, periods of flights, and flight routes. This new system can potentially provide vast amounts of information that can be used to build a map of the footprint of scientific research and its associated logistics. However, interpreting, entering, and processing the logistical information of 28 countries that are not always provided in the same format is no small feat. It is not an exhaustive list, however, and does not cover the activities carried out away from research stations. Thus, the true extent of activities carried out by national Antarctic programs is not represented. It is certain that national Antarctic programs retain records on the extent of their field programs, but because they are not required for Antarctic Treaty exchange, they have not been promulgated.

Tourism—A similar information system also exists for tourism activities. The International Association of Antarctica Tour Operators (IAATO) is an industry group comprising the large majority of Antarctic tour operators. Prior to each season, IAATO members provide information

to the association and collectively make use of a web-based ship scheduler to pre-schedule visits of each of their cruise ships to tourist sites. In addition, since 2008, the majority of IAATO vessels participate in a vessel tracking system (<http://www.iaato.org/operational.html>). Therefore, de facto, IAATO acts as a central repository of information on the capacity of tourist cruise ships, the routes they take, the numbers of visits at each site and the numbers of passengers landed there. While the information on the ship scheduler and the vessel tracking system is not publicly available, IAATO does collate and publish information on the sites visited and the numbers of tourists landed at each site at the end of each season.

Commercial Fishing—Commercial fishing activities are controlled through the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). Each year, the CCAMLR Secretariat receives information from their member countries on where, when, and how their fishing vessels fished. Depending on the area and the type of fishing that takes place, the information that is provided to the Secretariat varies. The details of the licensed fishing vessels are accessible to the public. The rest of the information is held by the CCAMLR Secretariat, and member countries can request the information following established rules of data access (Reid, personal communication; Graham, personal communication). Again, similar to the case of tourism activities, the CCAMLR Secretariat is to be a central repository for information on the trajectory of fishing vessels. However, due to its commercial sensitivity, the accessibility of this information is to be restricted.

Data Representation

A Geographical Information System (GIS) provides a powerful tool to compile, integrate, and analyze this information. Maps derived from the GIS can be used to represent the locations of research stations and intensities of activity. First, however, the information compiled in the Antarctic Treaty Secretariat's Electronic Information Exchange System must be re-formatted into data that can be loaded into a GIS. This is not a trivial task because of the complexities in converting the location coordinates into a GIS format, and a data model must be constructed for the descriptive data (the "attributes"). Once that has been done, the next challenge will be in representing it coherently so that it can be used for planning and decision making. The activities described above vary not only geographically but also in their duration, intensity, and, ultimately in their impacts on the environment, such as air quality, sight, sound, chemical residue, and wilderness values. A data model and a database can be constructed to store data representing these different features but representing them all on a map presents a severe challenge. Temporal elements, such as a fishing vessel that changes location during the one month that it is in the Southern Ocean, must be represented differently than a permanent research station.

Calculating the impacts of different activities must begin with understanding the nature of the activity and then observing or measuring the impact. Impacts on ecosystems can be measured by one of several well-established routines (e.g., Underwood 1994). Calculating the impact of an activity

on value systems such as wilderness values, however, means defining what is meant by “wilderness values” and establishing a measure of impact. Some tentative steps have been made toward proposing some definitions (Summerson and Riddle 2000; Codling 2001) but further research is needed. Calculating the intensities of impact of research stations with their resident populations and associated activities and those of tourists who arrive at specific sites over a period of 3 months, but not at all during the other 9 months of the year, represents a formidable challenge. This is complicated by the fact that while the location and intensity of tourist activities on land are well represented by the data compiled by IAATO, equivalent data on the activities of national Antarctic programs is not readily accessible. Distinguishing between infrastructure and activity reveals that the infrastructure of national Antarctic programs is well documented whereas the sites of field operations (activities) are not.

Figure 1 displays a small proportion of the data that are currently available on human infrastructure and activities in Antarctica. The data have not been weighted in any way and the information represented on the map is not to any scale. Only the geographical information is represented. Despite the simplicity and shortcomings of this figure, we hope that it demonstrates the potential power of such a tool.

Conclusions

We wrote this paper with more questions than answers in our minds. It appears that the good news is that information on major, current human activity in Antarctica is both accessible and reasonably well-maintained. However, the accessibility of this information varies greatly. From a purely technical standpoint, the first step in constructing a model of

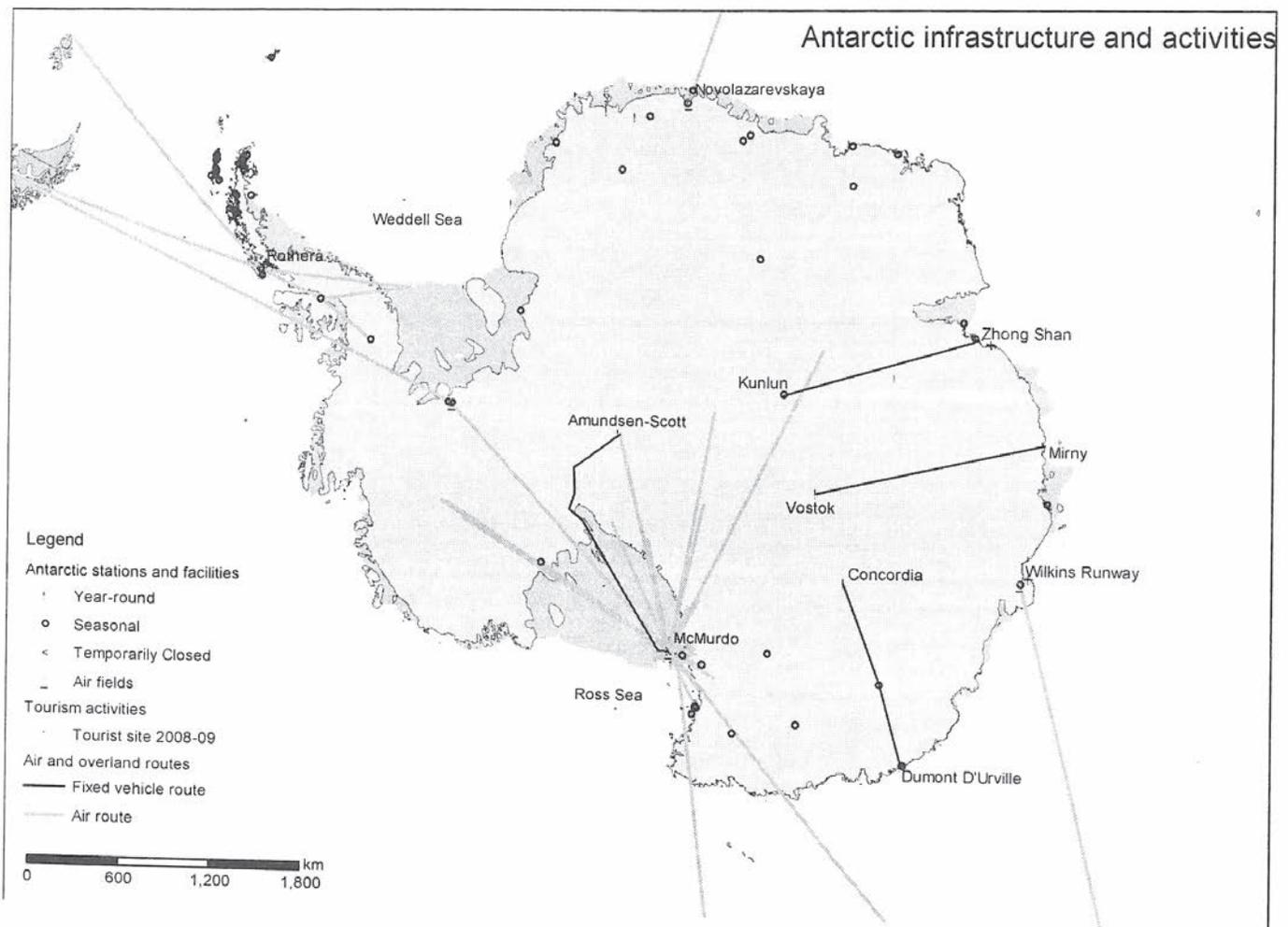


Figure 1—Map displaying a small proportion of the data available on human activities in Antarctica. Infrastructure and activities are represented by symbols that are not to scale. (Data sources: COMNAP, Scientific Committee on Antarctic Research (SCAR) Antarctic Digital Database, Australian Antarctic Division, Antarctic Treaty Secretariat, IAATO.)

the human footprint in Antarctica and the Southern Ocean consists of compiling data from the different information repositories in a common format. While this is not a small task, it only needs to be repeated once every 5 or 10 years, for the purposes of monitoring and planning. While it certainly does not paint a complete picture, if the infrastructure and activities of the national Antarctic programs could be assembled, maintained and disseminated, then a large part of the human footprint in Antarctica could already be defined more clearly and in a more transparent fashion.

In the course of the 9th World Wilderness Congress, the authors found that similar questions arise in the consideration of the impacts of human activities on the wilderness character of designated wilderness areas in the United States. Other researchers concur that GIS is a worthwhile and useful tool to help address this problem and agree that a great deal of research still needs to be done to arrive at a system that is clear, transparent, and reproducible and which can represent the impacts of human activities on wilderness character or values. However, our present examination of the case in Antarctica reveals that building the GIS database of infrastructure and activity is the first formidable challenge.

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