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# NEW SIGNIFICANCE FOR ANTARCTIC BIOLOGICAL COLLECTIONS AND TAXONOMIC RESEARCH

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***Abstract:*** Collections of preserved terrestrial and freshwater plants and animals, made since the earliest expeditions to the Antarctic and sub-Antarctic, have been the basis of our understanding of the biological composition of individual areas as well as of ecosystems in general. Systematic studies of these collections have elucidated patterns of evolution, dispersal and community structure in these southern polar biomes. During the modern era these collections continue to provide for taxonomic validation of pure and applied research in Antarctica. They are also becoming increasingly important as historical sources of information on ocean/atmosphere circulation changes, global "greenhouse" warming, ozone depletion and background levels of global pollution.

Representative collections of Antarctic organisms and the databases of ecological information associated with them are also vital for environmental management initiatives and the formulation of conservation policy in Antarctica. In the face of increasing scientific, logistic and tourist activity in the Antarctic and sub-Antarctic, protection of sensitive biota and ecosystems and control of human impacts are new imperatives recognized by the Antarctic Treaty under the Protocol on Environmental Protection.

The work of the British Antarctic Survey's (BAS) Resource Centre is highlighted and a summary of information on the BAS plant collections and computer database is given. The value of electronic datalinking between institutions with Antarctic collections is assessed, and the potential of Geographical Information Systems as frameworks for Antarctic biological databases is also discussed.

## 1. Introduction

Most early expeditions to the southern polar regions brought back small collections of flora and fauna, albeit often of the most conspicuous biota and often gathered by non-biologists. These served as the basis of our knowledge of these remote and inhospitable regions and stimulated much more comprehensive surveys of these lands and seas. These early collections and observations were used primarily for taxonomic purposes; they were the foundation of our understanding of the biological composition, evolution and biogeography of the present Antarctic and sub-Antarctic flora and fauna, and of the biological relationships between these far southern lands and the rest of the world. Until the beginning of the "scientific era" in Antarctica in the late 1940s very few biologists visited these regions and most were primarily concerned with making

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representative collections of the biota from specific localities solely for taxonomic studies. Once a more ecological, and later physiological, approach to Antarctic biological research became established in the 1960s, there was a much more functional attitude towards the collection of terrestrial plants and animals. However, the earlier collections that had been accumulated in a largely *ad hoc* manner, were in increasingly urgent need of reliable taxonomic assessment.

Progress in ecological and physiological studies can be seriously inhibited by the lack of accurate determinations (see LLANO, 1956; ANDO, 1979). In recent years there has been an increasing scientific need to establish biological baselines to provide a reference state against which subsequent changes may be compared (ABBOTT and BENNINGHOFF, 1990). This requires accurate inventories of biota based on sound taxonomic principles and expertise. Only then can changes in distribution patterns and ecosystem structure, and ecological and physiological process rates, particularly of ecologically important species, in relation to current trends in climate change and ice recession be sensibly and reliably detected. There are critical questions of global concern which are being addressed through monitoring studies of key indicator species in Antarctica because of the continent's importance in influencing the planet's ocean/atmosphere circulation patterns. Furthermore, systematic biology is becoming increasingly valuable in developing environmental and conservation policies. The Protocol on Environmental Protection to the Antarctic Treaty (see SENATE, 1992) requires biological input for environmental impact assessments of all human activities, ranging from scientific projects to the development of research stations or logistic installations, as well as for management plans of all protected areas.

The aim of this paper is to present an overview of the importance of biological collections in current research, and their value in supporting major environmental issues relating to Man's rapidly increasing involvement in Antarctica and the sub-Antarctic islands. Examples are drawn mainly from the field of terrestrial botany. The scope of this review encompasses spatial, temporal, and ecological data associated with Antarctic biological collections, as well as the specimens themselves.

## 2. The Traditional Roles of Antarctic Biological Collections

Collections of plants and animals from the far south have been made since the earliest days of exploration in the region. These have been housed in museums, herbaria and other research institutions around the world, and have been the foundation of all subsequent research on the biology and ecology of biota of the Antarctic and sub-Antarctic biomes. Assessment of these collections has extended knowledge of the taxonomy, distribution and relationships of the floras and faunas of the southern continental landmasses, for some to the physiological limit of life on Earth. In many instances such studies have revealed aspects of uniqueness in the biogeography of the region. In the field of botany examples include the circum-sub-Antarctic distribution patterns of several species of phanerogams (WACE, 1965) and most macrofungi (PEGLER *et al.*, 1980), the Antarctic distribution of numerous lichen genera (LAMB, 1964, 1968; WALKER, 1985; SMITH and ØVSTEDAL, 1991), several moss genera (GREENE *et al.*, 1968) and of liverworts (SCHUSTER, 1985; OCHYRA and VÁNĂ, 1989). In the field of invertebrate zoology examples range from the extensive studies of Antarctic and sub-Antarctic arthropod biogeography by GRESSITT (1965, 1970) to those of protozoans (SMITH, 1978) and rotifers (DARTNELL, 1983; DARTNELL and HOLLOWDAY, 1985).

Far from being exhausted, however, this exploratory phase of taxonomic investigation and analysis needs added impetus at present, for several reasons. There are still many ice-free areas on the continent about which nothing is known of the biota although, because of the low species diversity in such habitats, large numbers of new species are not to be expected. Indeed, as a result of the current resurgence in taxonomic revisions of certain groups (notably lichens), there may be a contraction in numbers of taxa where synonymy has arisen as a result of collections being made by biologists of different nationalities, at different times and in widely separate localities.

However, although several localities around the Antarctic continent and maritime Antarctic islands have been permanently occupied and their biota intensively studied for several decades, the composition and identity of the terrestrial flora and fauna remain poorly known. While the assessment of the early biological surveys was largely systematic in nature, as ecologically- and physiologically-oriented research developed the importance of taxonomy waned. During the 1970s and 1980s governments and research institutions in general regarded such research as unproductive and of little value, and that the provision of resources to advance our knowledge of the Antarctic biota could not be justified. Fortunately, this trend has been reversed in recent years, and there has been a resurgence of taxonomic research in Antarctica which should receive even greater support as concern for understanding global biodiversity grows. For example, although biologists from several nations have been working in the relatively floristically rich South Orkney and South Shetland Islands for over 40 years, the known bryophyte, lichen and freshwater alga (especially Chlorophyceae and Xanthophyceae) floras of these archipelagoes are still relatively poorly known. However, recent ecological surveys and associated taxonomic studies have more than doubled the number of lichen species at individual islands, *e.g.* for King George Island (GUZMÁN and REDON, 1981; JACOBSEN and KAPPEN, 1988; OLECH, 1989a; INOUE, 1993), Livingston Island (OLECH, 1989b; SANCHO *et al.*, 1990), Deception Island (APTROOT, 1992), Signy Island (ØVSTEDAL and SMITH, in preparation). This is also true for the bryoflora of these regions, although much of this work remains unpublished at present (R. I. Lewis SMITH, unpublished data).

Another important requirement for more comprehensive and critical Antarctic systematic studies is to provide a sound taxonomic basis for the increasing physiological and ecological work that is being carried out on Antarctic organisms. Much of this work is relevant to environmental issues of global significance. Accurate identification and knowledge of the relationships of experimental organisms is therefore crucial for the validation of results from such studies. However, this simple requirement may often be difficult to achieve. Among cryptogamic plants, for example, Antarctic environmental conditions (extremes of temperature and moisture availability, wind erosion, chemical enrichment near animal colonies, invertebrate grazing, fungal parasitism and, increasingly, exposure to high levels of UV-B radiation in early summer when ozone depletion is greatest) lead to high phenotypic variability, and/or poor development and sterility in populations, and thus difficulty in systematic definition (SEPPELT and KANDA,

1986; HERTEL, 1988, 1990; KANDA, 1990). Comprehensive biological collections which encompass the range of variability displayed by organisms are therefore vital for the solution of problems of identification arising through the above causes. Many of the taxonomic and phytogeographical problems relating particularly to bryophytes may be solved by laboratory culture studies, especially if sporophyte development can be induced.

## 3. Current Research Developments

Selected examples are given here to illustrate the role that collections of Antarctic biological material can play in contributing to the assessment of global and Antarctic environmental problems.

### *3.1. Global environmental concerns*

#### 3.1.1. Climate change

There is currently particular concern regarding the potential effects of increasing levels of "greenhouse" gases and their influence on global climatic warming. A large body of research is being focused on understanding these effects on biota and biological systems, and on predicting the nature and scale of change. While most research on the biological aspects of this phenomenon is being concentrated in the warmer biomes of the world and on species of economic importance, the Antarctic is an ideal natural "laboratory" in which to examine fundamental responses of biota and biological and ecosystem processes to climate change. Indeed, the Southern Ocean has been identified as a key region for the study of world carbon and heat flux and consequently a considerable amount of research is being undertaken in this part of the world, particularly in the vicinity of the sea ice margin zone (see HARRIS and STONEHOUSE, 1991). Many studies are being directed towards the identification of key indicator species which respond rapidly to minor fluctuations in sea temperature, chemistry, currents and UV-B radiation. In this respect various species of phytoplankton have been found to be valuable indicators of such changes, and so taxonomic research, on both present day and historical collections, to provide the accurate identification of diatoms (*e.g. Coscinodiscus bouvet*, see PRIDDLE and THOMAS, 1989) and other marine microalgae (*e.g. Phaeocystis pouchetii*, see MARCHANT *et al.*, 1991) has suddenly become of crucial importance. The selection and monitoring of key indicator species (microbe, plant and animal) which are likely to be sensitive to changes in the climatic regime of the Antarctic marine and terrestrial ecosystems has been recognized as a primary objective of the Antarctic Programme of the Detection and Monitoring of Global Change in Antarctica component of the International Geosphere Biosphere Programme.

There are an increasing number of changes in the balance of terrestrial ecosystem structure and functioning being reported. For example, a recent warming trend and a decrease in precipitation have been noted in the region of the sub-Antarctic Prince Edward Islands, and changes in the ocean and atmospheric circulation patterns are also predicted in this area of the south Indian Ocean. SMITH and STEENKAMP (1990) have provided evidence that increasing temperatures have been responsible for ecological changes on the islands. These include the rapid increase in the abundance of the alien mouse population which is predicted to lead to increased soil invertebrate predation and the consequent reduction in the rate of nutrient cycling and an imbalance between primary production and decomposition. Changes in the atmospheric circulation pattern, both recent and historical, are considered responsible for the introduction of new insect species and the various geographical elements in the insect fauna of the sub-Antarctic islands (CHOWN, 1990). One of these, the diamondback moth *Plutella xylostella*, has recently established a large and increasing population on Marion Island, and the larvae of this species are causing a serious decline in the regionally endemic host plant *Pringlea antiscorbutica* (CRAFFORD and CHOWN, 1990). At Signy Island the native grass *Deschampsia antarctica* and alien dipteran chironomid, *Eretmoptera murphyii*, have been spreading rapidly during the past 20 years, while the mosses *Polytrichum longisetum*, new to the Antarctic, and *P. piliferum* have, through natural causes, become established on recently deglaciated soil (R. I. Lewis SMITH, unpublished data). The success of these and other species has been attributed to the current warming trend experienced during the summers in this region (SMITH, 1990). Each of these, and many ecologically important species would merit detailed experimental study using standardised techniques to determine the optimal conditions and thresholds for physiological, reproductive and growth processes, and production of cryo- and UV-B protectants, in order to make predictions about their performance under enhanced living conditions. Clearly, such changes in the behaviour of individual species will lead to changes in ecosystem composition and structure, and understanding species performance must rely on experimental studies under controlled conditions. As an example, various lichens are used to determine the age of substrata in relation to ice recession and climate change, according to estimated growth rates. However, growth rate is dependent on, amongst other factors, summer temperature, moisture availability and radiation receipt. If there is a significant change in the trend of these parameters, annual incremental and biomass production will correspondingly change, thereby altering the growth curve. Thus, for lichenometry to be applied meaningfully, not only is it essential to have the accurate identification of the monitored plant so that comparisons may be made with the same species elsewhere, but also the growth characteristics must be reliably known if they are to be correlated with climate change.

Also, where possible, analysis of historical material and records contained in biological resource centres may be used to establish floristic and faunistic profiles against which to gauge future changes in species composition and performance. For example, the extensive and systematically grid-mapped "field records" of plant specimens collected on South Georgia and held in the herbarium of the British Antarctic Survey, are an example of a potentially valuable resource for a study of this nature. However, it must be emphasised that detection of temporal or spatial floristic (or faunistic) change in any specific area is dependent on very comprehensive initial surveys to provide a reliable baseline. This can probably be accurately achieved only in small permanent plots. The hyperoceanic sub-Antarctic islands are particularly suitable for climatic/biotic monitoring studies of this kind, because of their highly buffered isothermal climates and their remoteness from continental influences (climatic, human and natural biotic).

3.1.2. Pollution

Mosses and lichens are well known for their capacity to accumulate minerals and, for this reason, are commonly used in geochemical detection and in monitoring the aerial deposition or terrestrial uptake of chemical pollutants. However, Antarctica is generally remote from major sources of pollution, and this has attracted scientists wishing to measure global "baseline" levels of contaminants, because of the largely negligible levels of heavy metal and organic pollutants in the southern polar regions. It also offers ideal opportunities to analyse the impact of human activity on a local scale, particularly with regard to gaseous emissions from research stations and associated vehicles etc. Terrestrial plants (especially macrolichens) have been used as indicators of local heavy metal contamination emanating from Antarctic stations (SMITH, 1989; OLECH, 1991), while spatial deposition of cement dust associated with the construction of a station has been monitored in terms of damage to selected lichens and mosses (ADAMSON and SEPPELT, 1990). Mosses and lichens at Antarctic sites have also been used as indicators of the global circulation of chlorinated hydrocarbon residues (FOCARDI *et al.*, 1991). However, different species were used at each site which may affect the validity of the data. The use of suitable plants as bioindicator is likely to be employed increasingly as a tool in monitoring pollution trends in environmental impact assessments of Antarctic operations and installations. Reliable taxonomic information will be essential for such studies as different species have different adsorptive and mineral and gaseous uptake characteristics. For example, the recent study (SMITH, 1989) of local heavy metal deposition associated with the operation of the British Antarctic Survey research station Rothera and the subsequent construction of a crushed rock airstrip was based on the analysis of the dominant black fruticose circumpolar lichen *Usnea sphacelata*. This has subsequently been found to possibly include the virtually identical taxon *U. subantarctica* (distinguishable from the former species in the field only by the presence of apothecia). Existing herbarium collections can provide valuable historical material in such studies, as they may be analysed in order to obtain prior pollutant profiles and so establish the necessary baselines from which expected changes may be compared.

3.1.3. Ozone depletion

Herbaria have also provided the time-series of material needed to study plant response to changes in the levels of stratospheric ozone over Antarctica. MARKHAM *et al.* (1990) have demonstrated a negative correlation between UV-protective flavonoid pigments in the moss *Bryum argenteum* in the Antarctic, and ozone levels as calculated from UV-B radiation measurements since the 1960s. This potential "ozone-biomonitoring" capability of mosses is being further examined by the analysis of herbarium specimens collected earlier than the International Geophysical Year (1957–58) when ozone measurements began in Antarctica, and includes specimens of *B. argenteum* from the 1890s (K. R. MARKHAM and R. I. Lewis SMITH, unpublished data). The objective is to obtain an indication of possible natural fluctuations in ozone concentration against which to chart current and future changes being caused by anthropogenic release of chlorofluorocarbons into the atmosphere.

While its cosmopolitan distribution makes *Bryum argenteum* a valuable research tool for global comparisons, it is a diminutive species with a surprisingly widespread but somewhat disjunct distribution in Antarctica. The three predominant circum-Antarctic mosses *Bryum pseudotriquetrum*, *Ceratodon purpureus* and *Schistidium antarctici* would be better suited for analytical purposes. However, the taxonomic status of these is uncertain and each of these genera contain groups of nearly identical taxa described in the literature as distinct species. Almost certainly critical revision of these will reveal that most belong to the same species in the respective genera. The cosmopolitan *B. pseudotriquetrum*, for example, is widespread throughout coastal areas south of 60°S, and occurs conveniently across the boundary of the Antarctic ozone "hole". However, it is a notoriously variable and difficult species taxonomically (ANDO, 1979; OCHI, 1979; SEPPELT and KANDA, 1986), and is only rarely found in fruit in continental Antarctica (fertile specimens are necessary for accurate identification). Initial qualitative studies of the flavonoid content of *B. pseudotriquetrum* (K. R. MARKHAM, pers. comm.) and scanning electron microscopy of surface wax ornament (S. RUSSELL, unpublished data), reveal heterogeneous patterns of variation that cast doubt on the validity of the single species concept in this taxon. Indeed, there is evidence of biochemical and isozyme differences within plants of the same apparent clonal population. As with many other Antarctica genera, both of bryophytes and lichens, there is an urgent need for critical taxonomic studies (traditional, chromatographic, isozyme, DNA fingerprinting, etc.) on the macrocryptogamic flora to establish their true identity and the genetic or evolutionary relationships of closely related taxa). This is essential before the value of indicator species as potential ozone (or other environmental) biomonitoring organisms can be fully assessed.

*3.2. Antarctic environmental concerns*

The above examples represent some of the local and global-scale problem areas in which Antarctic biological collections are making contributions to research. Detailed knowledge of individual plant and animal species distributions are also of importance for environmental and protected area management. Two main areas of concern are the rapidly increasing tourist industry and expanding scientific and associated logistic activity on the Antarctic continent and adjacent islands, especially in the Antarctic Peninsula region.

The development of large-scale but generally well-organised cruise ship tourism brings large numbers of visitors to localities in the Antarctic and sub-Antarctic, while small private adventure expeditions using yachts and aircraft bring small numbers to much more remote sites. Because of their scenic and wildlife values several biologically rich but ecologically sensitive and fragile systems have been selected by tour operators as sites of major attraction to tourists. The Scientific Committee for Antarctic Research is attempting to promote the designation of special tourist areas where human impact on the environment and biota will be scientifically monitored with particular regard to ecosystem resilience and recovery. Again, the use of selected indicator species and long-term study plots will play an important role in such a programme.

The increase in the number of nations engaged in scientific research in Antarctica has also added to human impacts, as most research stations are built in the same ice-free areas that are the principal habitat for terrestrial organisms on the continent and islands, *e.g.* alga/moss/lichen/invertebrate communities, and breeding seabird and seal colonies. For example, three nations operate base stations in close proximity in the Schirmacher Oasis, Dronning Maud Land, three more in the Larsemann Hills, Princess Elizabeth Land, and nine nations operate stations at King George Island, in the South Shetland Islands, where there are some of the best developed and most extensive vegetation stands in the archipelago. Environmental impacts associated with such concentrations of activity include construction operations, personnel and vehicle movements, fuel storage leaks, waste disposal and uncontrolled gaseous emissions from waste incineration, and the threat of unintentional introductions of organisms. Carefully controlled environmental management at such sites is essential since the ecosystems close to research stations are most frequently chosen for scientific study, and in some instances are an attraction for tourist visits. However, precautions have been taken to avoid environmental perturbation and conservation of biota and ecosystems since the Antarctic Treaty entered into force in 1961. Such protection has been more rigorously implemented under the new Protocol on Environmental Protection to the Antarctic Treaty. Reliable information on species and community distributions in these and other local, but so far unsurveyed, areas is therefore necessary to help identify and categorize such habitats. This will be crucial for the planning and control of human activities, and the designation and delimitation of areas worthy of special protection. Such information on the biological composition and status of Antarctic Specially Protected Areas (ASPAs) is an essential requirement for the management plans of Specially Protected Areas (SPAs) and Sites of Special Scientific Interest (SSSIs) as specified in Article 5 of Annex V of the Protocol (see SENATE, 1992).

Information from existing biological collections, combined with basic ecological survey work, has thus become of fundamental importance in providing baseline data for site management plans, and codes of conduct for scientific and logistic activity. Such data have also been used in the Environmental Impact Assessment process required by the Antarctic Treaty for the modification of existing research stations, construction of new stations or associated facilities and execution of major research programmes. They may also serve as the basis for proposing new protected areas.

## 4. Case Study: the Antarctic Resource Centre of the British Antarctic Survey (BAS)

The Antarctic Resource Centre (ARC) is an important facility of the British Antarctic Survey's Terrestrial and Freshwater Life Sciences Division. It has proved to be a valuable source of data for activities such as those outlined above, and an important repository for Antarctic and sub-Antarctic terrestrial and freshwater biological specimens. The major component of ARC is the British Antarctic Survey's herbarium (international code AAS) which contains probably the largest collection of austropolar plant specimens and records in the world (approximately 25000 bryophytes, 15000 lichens, 2000 vascular plants, 250 macrofungi and a small number of algae). The specimens are mainly from Antarctica and the peri-Antarctic islands, with additional representation, acquired through exchanges, of relevant taxa from the neighbouring southern continents.

The bulk of the holdings are from very extensive collections made throughout the sector between 20° and 90°W, including many continental inland ice-free areas. Bryophyte and lichen collections are particularly strong for South Georgia, South Sandwich, South Orkney and South Shetland Islands, and the Antarctic Peninsula and offshore islands. These represent the collections of about 60 individual researchers, including the important large collections of B. G. BELL, S. W. GREENE, D. C. LINDSAY, R. E. LONGTON, and R. I. Lewis SMITH. The Centre also has substantial collections of terrestrial (*c.* 2000 samples) and freshwater (*c.* 500 samples) invertebrates, and a live culture collection of Antarctic algae, bacteria and fungi. A small number of living plant and invertebrate specimens are maintained under controlled conditions for use in laboratory-based experimental studies conducted by BAS and visiting scientists.

The ARC had its origin in plant and invertebrate (microarthropod) collections that began to accumulate as a result of *ad hoc* gatherings of specimens and ecological surveys carried out in the late 1950s and early 1960s. The herbarium was formally established in the mid-1960s under the curatorship of S. W. GREENE, who also initiated the Antarctic Plant Database (APD) based on a punched-tape information system (GREENE, 1972; GREENE and GREENE, 1975).

The APD is a taxonomic-geographic information storage facility that contains full collecting details of most of the specimens in AAS, together with several thousand field records for the South Georgia botanical survey and details of Antarctic specimens held in most other major herbaria around the world. The latter information, collated up to the mid-1970s, is useful for taxonomists wishing to know which herbaria have holdings of their study taxa. Since 1983 the APD was further developed by P. J. LIGHTOWLERS and operated on a mainframe computer using "STATUS" software (Harwell Computing Power Ltd., although this will soon be transferred to "ORACLE"). This bibliographic text-manipulation and retrieval system allows searching of the database for any word or combination of words. Information keyed by species, localities, ecological data, collectors, dates of collection, holdings in other herbaria, etc. can therefore be rapidly accessed (LIGHTOWLERS, 1988). It is intended that the database facilities within the ARC will be expanded to include other large numerical datasets derived from several long-running research projects. These include microclimate data (*e.g.* WALTON, 1977), soil (R. I. Lewis SMITH, unpublished data), lake and stream chemistry data (e.g. HEYWOOD *et al.*, 1979, 1980), quantitative data from plant community analyses (R. I. Lewis SMITH, unpublished data), as well as annotated bibliographies (*e.g.* WALTON, 1980; BLOCK, 1992).

The ARC has thus become a valuable resource for researchers internationally, and during the past few years there has been an increasing demand from scientists worldwide, for specimen loans from the herbarium and information from the database. As a result, several collaborative projects with specialists from other countries have resulted in numerous taxonomic publications on bryophytes, lichens and invertebrates. The primary use of the AAS collections and the associated database has been for basic taxonomic studies, which have been invaluable in assessing the biodiversity of specific sites, regions or ecosystems in Antarctica and the sub-Antarctic island of South Georgia. Distribution patterns of key species throughout the Antarctic biome have been elucidated and valuable contributions made to knowledge of their global biogeography. Taxonomic research has also provided the foundation of various monitoring projects, some of which have been running for over 25 years. These biological baselines are crucial for studies of ecological and environmental change.

In recent years there has been a heavy demand for biological and environmental data for environmental impact assessments (EIAs) and the preparation of management plans for protected areas in Antarctica. It is now a requirement of the Antarctic Treaty that all human activities in the region are assessed with regard to their potential impact on the environment and its biota. The ARC has been able to provide biological inventories for several EIAs conducted by BAS and for management plans for most SPAs and SSSIs in the maritime Antarctic region. The Resource Centre is therefore providing a major contribution to the development of rational conservation policies for the region. Another way in which this role can be extended is by use of database information to highlight areas of biotic diversity that might warrant special protection or could serve as important research or monitoring sites. Following a recent study of the environmental impact of human activities at King George Island in the South Shetland Islands (HARRIS, 1991a, b) a computer search was made of APD records for this locality. This yielded over 540 plant records from more than 20 localities on the island, providing a reasonable preliminary assessment of the flora of the island. A total of 70 records comprising 40 species was noted for Fildes Peninsula, close to the main concentration of scientific stations on the island. This is a high floristic diversity for a relatively small area, and the site is of sufficiently difficult access to deter casual visits. In view of the potential danger of human impact from the nearby concentration of research stations, civilian village, road network, year-round airport, and rapidly developing local tourist industry, these factors taken together suggest an area deserving of further study, with a view to assessment as a potential protected area or baseline-monitoring reserve. In 1991 the nearby Ardley Island, with its exceptionally diverse flora and fauna and consequent scientific importance, was designated a SSSI with a strict management plan because of its vulnerability to excessive human perturbation. The case for affording immediate protection was supported by earlier published floristic inventories (PIZARRO and SÁIZ, 1977; GUZMÁN and REDON, 1981).

## 5. Future Trends

From the examples given above it is clear that Antarctic biological collections will be utilized more frequently in the future to support pure and applied research and aid environmental assessments, not only in the Antarctic but also in the wider global context. After decades of neglect, the value of detailed and accurate biological inventories and monitoring to support the principles and practice of conservation has suddenly been realized and become a high priority research area in Antarctic (and global) science and environmental management. Accompanying the increased use of such archives in research, will be the need for faster and more efficient handling of and access to the data associated with the collections, and easier exchange of this information between researchers working in different countries and institutions. However, the value of these collections can only be realized if they are efficiently curated, accurately determined and the specimens and data made readily available to researchers worldwide. For this to be achieved national Antarctic organizations and institutions holding collections of Antarctic material should be urged to provide greater support for taxonomic research, using modern techniques, and the necessary facilities for curation and data handling. Greater liaison and collaboration between specialists around the world should be encouraged. There is an urgent need for accurate descriptive accounts, accompanied by good illustrations and identification keys, of all major plant and invertebrate groups. This is fundamental to biological research as well as to meaningful conservation and environmental practice. However, where biological surveys are planned for whatever purpose, collections must be carefully made by competent scientists so as to be representative of an area or site. It is important that such surveys are undertaken in a responsible way and with due regard to the conservation of the site. They should involve selective sampling by qualified biologists rather than "saturation sampling" whereby large numbers of specimens known to be of the same species are collected from a relatively small area.

The British Antarctic Survey's Resource Centre has traditionally made its data available, at no cost, to overseas researchers, in hard copy or, more recently, in diskette format. Modern developments in electronic data communication can, however, enable "instantaneous" transfers of information between centres around the world, and systems such as electronic-mail and satellite data-linking are being investigated by BAS and other Antarctic research institutions for their utility in this respect.

Further speed and efficiency in handling Antarctic environmental data can potentially be achieved by incorporation in a geographically referenced format, in a computerised Geographic Information System (GIS). Such systems offer the potential for integrating data from many sources *e.g.* species distributions, substrate geology, soil and water chemistry, climatic data, oceanography, glaciology, human activity, literature records etc., into a structure that allows rapid cross-referencing, comparisons and analyses at different scales, merge-listings and overlay mapping etc. GIS could thus be a powerful tool for environmental planning and management in the Antarctic, and is under investigation by several Antarctic Treaty nations at present. Several difficulties need to be overcome before the full potential of GIS can be realised in Antarctic scientific studies. For example, input problems arise as a result of differing standards and formats of data-collection that have been used over the years by different research groups. Different map projections, referencing techniques, erroneous coordinates, and incompatible methods of recording ecological data for specimen collections have caused problems in initial trials of GIS in Antarctic studies (C. M. Harris, pers. comm.).

Some of the problems of Antarctic data management are being addressed by the Scientific Committee on Antarctic Research (SCAR) *ad hoc* Committee on the Coordination of Antarctic Data which seeks to create a unified inventory of Antarctic data in order to assemble a directory of existing data sets and data archives. A survey of existing Antarctic specimen and data collections has been undertaken, and consideration is being given to the need for common standards and formats for Antarctic data collection and archiving, in accordance with Recommendation 16 of the XVth Antarctic Treaty Consultative Meeting (ATCM) which desired "to improve the accessibility and comparability of Antarctic scientific data....for use in facilitating environmental assessment and monitoring and the promotion of scientific research" (ATCM, 1989).

## 6. Conclusion

Antarctic biological collections have traditionally been used for basic taxonomic and biogeographic studies. They are increasingly being used to support investigations into global environmental problems such as ozone depletion, climate change and pollution. In addition, they are also providing valuable information for local environmental assessment and the formulation of conservation policy and protected area management plans, as the relatively pristine but highly sensitive ecosystems of Antarctica come under pressure from impacts caused by increasing scientific, logistic and tourist activities.

Analysis of data associated with Antarctic biological collections provides baseline information essential for monitoring studies, reveals gaps in knowledge of Antarctic biodiversity and provides supporting evidence for sites worthy of consideration as protected areas. With due attention paid to the standardisation of input formats, GIS techniques may be usefully integrated with biological database management to become a powerful tool for Antarctic environmental management. Electronic data-links will also increase the opportunities for international collaboration between scientists working on Antarctic biological collections, which will remain essential basic resources for research and biomonitoring throughout the Antarctic and sub-Antarctic biomes.

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