Wetland Ecosystems in Small Islands

by Peter Bridgewater

Small islands are especially vulnerable to problems with wetland ecosystems – why? Simply because many wetlands are fed by freshwater, this is seen as a competing use by islanders for their water sources. Wetlands are also vulnerable to pollution events, drainage, and invasion from alien species, and, especially in small and low islands, salt water intrusion to the fresh groundwater "lens". This places the future of island wetland ecosystems, and the biodiversity they support, in considerable jeopardy – in fact more so than the ecosystems typically regarded most at threat, such as forests.

This short article cannot do justice to the structure and function of freshwater ecosystems on small islands. So it is a pot-pourri, a somewhat eclectic mix of glimpses of some islands (not always individual states) and their biodiversity features, from the equator to the Poles, and some thoughts about the issues critical to the future of these ecological systems. Of course, it is true that, on islands especially, wetlands are controlled by the availability of water: and, in turn, exercise control over the availability of water. So a discussion of freshwater systems and their biological diversity must involve some discussion of the natural management of water on the islands. We can gain the best glimpses of Island systems through those areas protected under various international designations, such as Ramsar sites, World Heritage natural sites or sites in the World Network of Biosphere Reserves. Contact url's for web sites detailing these designations are provide at the end of the article.

But first, let us define what a wetland is. I use the definition followed by the Ramsar convention on wetlands (Ramsar, Iran, 1971) as the most authoritative globally. The definition is:

> "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

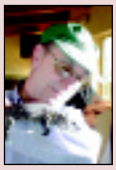
Aleutian Islands

As marine systems are being covered in a separate article I will confine my remarks chiefly to island freshwater wetlands. However, the small size of many islands means the connectivity and linkages between the different ecosystems are condensed, and of course, the linkage between terrestrial and coastal marine systems are more extensive, and intimate, than on continental land masses. There are many recent works dealing with these issues, but see (Bennett, A.F. 2003) for a good summary.

Many islands have complete sets of ecological systems, depending on the latitudinal position and geomorphology. Except for larger islands, however, the extent of many ecosystems is often restricted. And wetlands, in the form of swamps and mires, tend to be small in extent, and often ephemeral. Similarly rivers rarely have the opportunity to develop maturity, and lakes are rare, other than in exceptional locations.

Some examples

At the Equator, The Archipiélago de Colón (Galápagos Islands), is situated in the east Pacific Ocean, 1,000 km from the mainland of Ecuador, with the equator running through the Wolf and Ecuador volcanoes on Isabella Island. Situated on the Galapagos Submarine Platform, the Galapagos Islands consist of 13 islands. These islands were formed 4 million years ago by volcanic processes and most represent the summit of a volcano, some of which rise over 3,000 meters from the Pacific



Peter Bridgewater is Secretary General of the Ramsar Convention on Wetlands, and has been Director of the Unesco's Division of Ecological Sciences and Secretary of the Man and the Biosphere Programme (MaB).

Ocean floor. The larger islands typically comprise one or more gently sloping shield volcanoes, culminating in craters or calderas and the terrain are generally composed of uplifted marine lava flows. Freshwater is a critically limiting factor, and only San Cristobal has adequate perennial supplies for the local human population. Small wetlands occur on the islands in suitable locations. But this is a typical series of volcanic islands, where the predominant terrestrial vegetation is xeric, and wetland systems are small, and typically ephemeral. Yet they play a key role in the general flows of water through the groundwater aquifers, and their conservation and wise management is key to wise management of the aquifers.

In the southern hemisphere, Siberut is the largest in the chain of four Mentawai Islands situated off the west coast of Sumatra, Indonesia. It has been isolated from the Sumatra mainland and the Sunda shelf for at least 500,000 years, resulting in an exceptionally high degree of endemism: 65 % of the animals are though to be endemic. Lowland dipterocarp rain forest is the principal ecosystem. Despite that, there is also extensive riverine forest dominated by *Terminalia phellocarpa*; freshwater swamp and bog forest; and *Casuarina equisetifolia* damp forest close to the coast.

Further west, Mauritius, located in the Indian Ocean, is a larger island, with considerable settlement and anthropic changes over millennia and especially in the last few hundred years. While much of the remaining vegetation is composed of tropical moist forest at various altitudinal levels, there are some small lakes and wetlands, including marshlands characterized by *Lycopodium* spp., *Pandanus* spp., *Sphagnum* spp. etc. and at higher altitude damp *Philippia/Phylica* heath with *Astelia hemichrysa*, *Coffea* spp., and *Blechnum attenuatum* as key species.

Trinidad represents another island where forest is the dominant ecosystem, with increasing anthropic influences. Nariva swamp in is a very good example of a large swamp forest ecosystem characteristic of the Caribbean region. The site also supports one of the only two communities in Trinidad and Tobago of the *moriche* palm *Mauritia* spp. The site regularly supports large numbers of

members of the Ciconiiformes, including the families Ardeidae, Cochleariidae and Threskiornithidae. Mammal species include *Alouatta seniculus*, *Cebus albifrons* and *Agouti paca.* Reptiles include *Caiman crocodilus, Eunectes murinus* and *Iguana iguana*. The major vegetation types permanent herbaceous swamp with *Montrichardia arborescens* and *Cyperus giganteus*, seasonally flooded forests with *Eleocharis mutata, Cyperus odoratus* and *Phragmites* spp., swamp forest with *Pterocarpus officinalis, Carapa* spp. and *Bactris major* and islands of humid tropical forest with *Roystonea oleracea*, *Mauritia setigera* and *Euterpe oleracea* and *E. precatoria*. The site also hosts many bird species, and 32 species of bats.

Across the pacific the islands of Micronesia and Polynesia form extensive chains. Many are small, often simple coral atolls with no freshwater resources at surface. Yet others have a volcanic base, and there wetland systems, even lakes, can develop, as well as riverine features. In Palau, for example, Lake Ngardok is a small, natural, freshwater lake on Babeldaob island with some swamp vegetation and is the largest permanent freshwater body in Palau. It supports indigenous fishes representative of Palauan fish fauna and has a small breeding population of the estuarine crocodile *Crocodylus porosus.* This lake is a Ramsar site, and includes the entire protected Nature Reserve and catchment of the lake, and thus also includes several streams and small areas of riverine marsh and freshwater swamp forest as well. The lake is particularly important for control of floods and maintenance of water quality, and at least 11 indigenous bird species are supported as well, including the national bird, the Palau Fruit Dove or "biib" (*Ptilinopus pelewensis*).

In the sub-tropical zones, the Spanish Canary Islands are interesting examples. Situated off of Morocco, but belonging to Spain, they are classic islands for showing a contrast in ecosystems. At lower levels the islands are dominated by coastal matorral with *Euphorbia balsamifera, E. broussonetii, E. canarensis* and *Plocama pendula*, yet where trade winds meet island mountains, the moisture laden air condenses causing clouds or mist to form at elevation, giving rides to cloud forests, creating a typical and

unique laurel Forest. Typical species include *with Laurus azorica, Ocotea foetens, Persea indica, Myrica faya, Erica arborea, Ilex canariensis* and *Picconia excelsa*.

This exists as a luxuriant damp forest, simply because of the water condensing from the fog and mist. The aboriginal in habitants of the islands knew full well the importance of this water source, and, on one island, El Hierro, a very large tree was essentially the human water source for the whole island, and so revered as a sacred site. Although these forests are not wetlands as such they illustrate the ways in which climate, landform and vegetation interact to promote a water cycle, which in turn drives other systems, including small marshes and wetlands. The adjacent island of La Palma illustrates another feature – the development at higher altitudes of montane mires and wetlands, including species such as the ferns *Cheilanthes guanchica, Asplenium adiantum-nigrum* and *A. onopteris*, and flowering plants such as *Viola palmensis, Nepeta leydea, Spartocytisus supranubius and Plantago webbi.*

The "Garoé", holy tree of the island of El Hierro that represents the importance of water in some islands.

In higher latitudes of the northern hemisphere island systems can be quite rich in wetland related systems, specially mires, bogs, wet heath and bog forests. The West Estonian Archipelago is such an example, situated in the eastern Baltic Sea and its terrestrial habitats contain pine forests, mixed spruce and deciduous forests, juniper and coastal meadows, swamps and peat bogs. Parts of the archipelago are also designated as Ramsar wetlands. The admixture of forest and wetland is an interesting feature of the island.

The Commander Islands are situated in the Bering Sea east of the Kamchatka Peninsula and includes mountain tundra, motley-grass meadows, wetlands, coastal and marine zones. The flora and fauna of Commander Islands are remarkable because of the unusual combination of species of Asian and American origin, and most can be classified as wetland systems. Mountain tundra covered by heathers with crowberry, characterized by *Arctous alpina, Rhodonendron camtchatica, Rhododendron aurea, Loiseleria procumbens* etc.; Motley-grass meadows with *Calamagrostis langsdorffii, Anemone villosissima, Geranium erianthum* etc.; lakes, rivers, swamps including sedges (*Carex* sp.), cotton grass (*Eriophorum* sp.), willows (*Salix* sp.), sphagnum moss (*Sphagnum* sp.) etc.;

Further east and north, are the Aleutian Islands. The islands are typically treeless with subarctic alpine vegetation in montane areas. Typically, lower mountain slopes and waterway margins are vegetated with *Alnus crispa* and sparse growths of *Salix* spp. Vegetation of the coastal plain and glacial outwash areas is composed of species such as *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Calamagrostis canadensis*, *Eriophorum scheuchzeri*, *Salix* spp., *Cladonia* spp. and *Sphagnum* spp. Wet meadows and marshes are dominated by *Elymus arenaria*, while the lagoons are fringed by *Carex* spp. Important terrestrial mammal species using the Refuge include *Rangifer tarandus*, *Ursus arctos*, *Lagopus lagopus*, *Gulo gulo*, *Mustela vison*, *Lutra canadensis* and *Canis lupus*. The birds *Haliaeetus leucocephalus* and *Falco peregrinus pealei* are year-round residents. These islands have a complete admixture of Asian and American species

In the southern hemisphere at the same latitudes there are sub-Antarctic islands, all of which have extensive mire and wet grassland ecosystems, remarkably similar vegetation despite the islands being thousands of kilometers apart. Lack of any large landmasses means a constant oceanic climate. These islands and their ecosystems have all been impacted by the casual, but brutal contact from people, with a range of introduced animals and plants causing destabilisation to the island ecosystems

Macquarie Island is south of Tasmania, and is one such island. Five main vegetation formations have been described, tall-tussock grassland, short tussock grassland (herbfield), fen, bog and feldmark. While the distribution of these formations generally reflects the island's topography introduced European rabbits have severely modified some of them. On the exposed summit plateau, covering around 50% of the island, the ground cover varies from 5% to over 50% and is dominated by the endemic, cushion forming *Azorella macquariensis* in the more sheltered sites and increasingly by cushion forming mosses as the wind exposure increases; lakes, pools and mires are abundant. The ionic composition of most lakes reflects oceanic influences on the reserve. Many lakes lack streams to feed them and/or outflowing streams, explained by the porous nature of the rock and dipping rock strata.

Some smaller species of burrow-nesting seabirds breed in the larger cushions. In the closed fen and bog formations decomposition rates are slow with peat beds being over 6m deep in places. An endemic orchid is found in these formations. Small patches of sphagnum moss have been rapidly increasing in area in recent years, which has been attributed to global warming.

Environmental threats and opportunities for island wetland ecosystems

Freshwater availability

Despite the relatively high rainfall received by many SIDS a considerable number experience freshwater shortages. Small islands frequently have a relatively limited capacity to store water for use in the dry season, and the construction of large reservoirs is often difficult from an engineering perspective, and takes up valuable land. In addition, torrential rains, coupled with steep topography, short river channels and easily eroded soils, can cause rapid siltation of reservoirs.

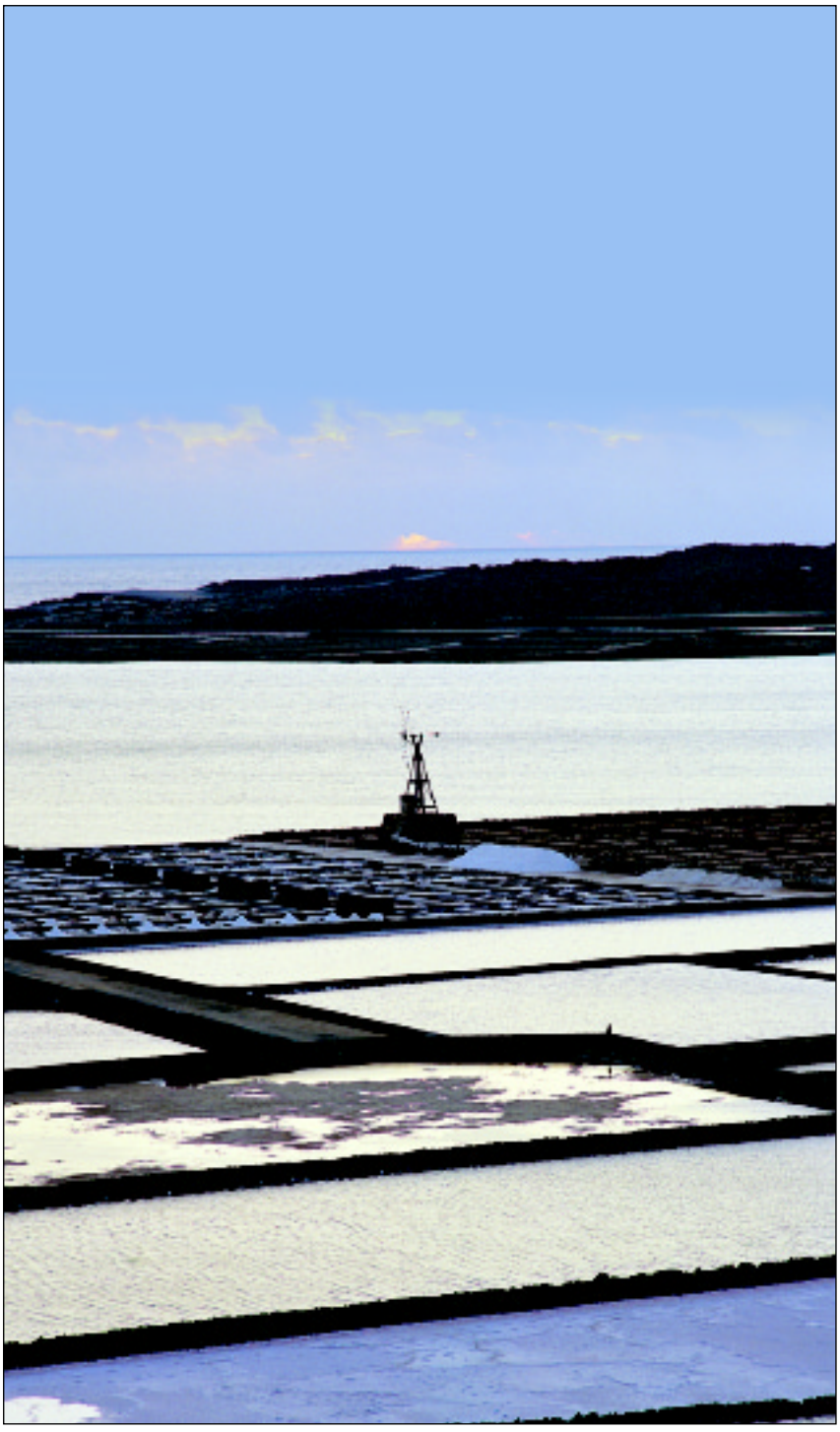
SIDS therefore depend heavily on groundwater resources which typically exist as freshwater 'lenses' containing limited quantities of water. However, as noted above, withdrawal rates that exceed the sustainable water yield can result in temporary or permanent sea water intrusion, thereby damaging or destroying the freshwater lenses. Given that small islands are surrounded on all sides by marine water, this makes saltwater intrusion into groundwater resources very likely, and the possibilities of then contaminating ecosystems fed by groundwater flow or springs is very high.

The populations of small islands tend to be concentrated on the more gently sloping lands along the coastline. The resulting high population density can cause problems with groundwater supplies which can easily become contaminated by poor sanitation. Increased use of pesticides and fertilizers, as well as leachate from solid waste disposal sites, are additional pollution hazards to ground and surface water in many islands.

Tourism

Opportunities for economic diversification in SIDS are often limited, and many depend heavily on international trade, including tourism, for their economic viability. At the same time, the successful promotion of tourism is strongly correlated with the quality, ambience and aesthetic value of the environment. In most cases, both amenity value and aesthetic ambience are related to the quality of freshwater resources, as well as the ecosystems they support. Despite its obvious economic potential, the development of tourism can also have negative impacts on freshwater resources, including high water consumption and a corresponding increase in the generation of wastewater.

The Janubio's saltworks. Lanzarote island.



Orongo Crater, Easter Island

Environmental protection

Lack of drainage basin controls or environmental protection, coupled with economic development (such as tourism, agriculture, industry) can severely reduce the spatial extent of the drainage basins that are vital to freshwater supplies. Further, many of the hydrological studies and investigations carried out on small islands are thus based on criteria and concepts more appropriate to large islands or continents than to the needs of small islands and water projects are often implemented without accurate knowledge of the available (and sustainable) water resources. Island-specific or, in favourable cases, regional studies are required to identify the available water resources and to implement effective development and management programmes.

Island Systems Management

The diminutive size of SIDS means that development and freshwater resources are closely related and interlinked. Water resource management must therefore seek to rationalize the use of island resources with the goals of sustainable development. An appropriate framework for this is provided by the Island Systems Management (ISM), which was developed by the Organization of the Eastern Caribbean States and adopted by the First Ministerial Meeting on the Implementation for the Barbados Programme of Action (held in Barbados in November 1997).

The ISM is a multi-disciplinary, multi-faceted mechanism offering an adaptive management strategy which both addresses the issue of resource-use conflicts and provides the necessary policy orientation to control the impacts of human intervention on the physical environment. The effectiveness of ISM is dependent upon an institutional and legal framework which coordinates the initiatives of all sectors, both public and private, to ensure the attainment of common goals through a unified approach.

Another complication is that there are often several organizations involved in, and responsible for, the various aspects of water resources. Data collection, health issues, service delivery, environmental management and other activities are generally delegated to different government agencies, many of whom rarely talk to or consult each other. In addition, their programmes are rarely integrated with those of other organizations whose activities may impact on water resources, such as tourism, land-use planning and human settlements. All these factors contribute to the absence of an integrated approach to water management.

Many of the biodiversity country studies and reports have details on freshwater resources and ecosystem. One example is that of the Country study of St. Lucia [1]

• St. Lucia's Biodiversity Country Study Report finds that

"Freshwater habitats in St. Lucia include thirty-seven major rivers, some temporary and permanent streams, marshes, swamps, underground springs, flood plains, inland mangroves and the constructed systems, such

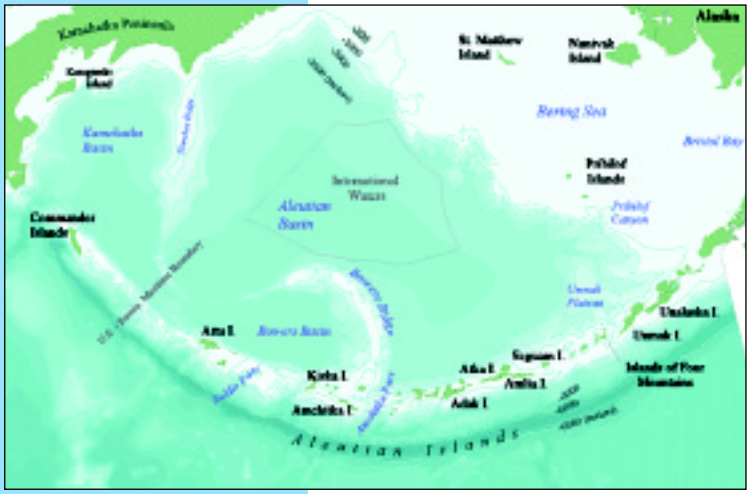
[1] http://www.slubiodiv.org/Biodiversity_Project/Information/Printed_Materials/Country_Study_Report/country_study_report.html

as the John Compton Dam, the Rodney Bay Sewerage Treatment Ponds (RBSTP) and several irrigation and aquaculture ponds. The aquatic habitats in St. Lucia suffer from similar forces of destruction as do other rivers and wetlands all over the world.

Wetlands play significant roles in water purification, sediment removal and flood control. The sponge-like action of swamps often facilitates the slowing down of surface run-off, the extraction of organic and inorganic compounds and the deposition of suspended solids. As the country's population grows, water extraction by the water authority and farming sector is increasing.

In recent years, this increased extraction of water has become evident by the reduced base flow of rivers and streams and by the complete drying up of small streams and wetland areas in the dry season. The practice of draining and drying wetlands for the purposes of construction and land reclamation is also a contributor to the reduction in the volume of water available for use on the island.

Wetland transformation has been ongoing in St. Lucia for many years. What was once the Sans Soucis swamp, for example, is now a large residential and commercial centre. The Rodney Bay area, once only marsh land and swamp, is now partially drained and is a significant contributor to the tourism and commercial business of the Gros Islet region.



Threats to the freshwater ecosystems come not only from activities that extract water from habitats but include many activities which add components to, and impact significantly on the aquatic habitats. Effluent disposal by sewage treatment plants and domestic septic tanks add organic matter and microbes to rivers and wetlands. Organic enrichment can cause de-oxygenation of the water. Microbes may lead to disease outbreaks in aquatic plants and animals and/or may infect secondary and tertiary users of the ecosystems.

Untreated wastes from factories are often released into rivers, leading to severe changes in the temperature, chemical and/or physical state of the aquatic systems, most often threatening habitat stability and biodiversity. Inappropriate hillside agriculture and building construction cause topsoil disturbance and runoff during rainfall. The sediment loads of most rivers around the island, especially those within agricultural belts are, as a result, very high. Agro-chemical contamination of most of the island's freshwater resources is also high.

The freshwater ecosystems in St. Lucia are home to birds, fish, shrimp, insects and

Azores

Falkland Islands

molluscs. Many of the birds which nest and forage in the wetlands are migratory but most of them are resident on the island. Little is known about the freshwater fish. There are few recorded species but those that are known have been observed to live in even the most degraded habitats. The need to further study the island's fresh and brackish water fish and their lifecycles is, therefore, worthy of mention. There are thirteen species of freshwater shrimp recorded for St. Lucia and these are found in every type of wetland system that has a link with the sea. These animals are often targeted for fishing despite Fisheries Regulations that prohibit their capture and sale. Tolerance levels for pollutants are observed to be low in the shrimp but their recolonization rates seem to be high. The insects and snails are found island-wide but their distribution patterns have been observed to be clearly associated with the pollution levels of their habitats.

The Water and Sewerage Authority (WASA) is responsible for the protection of the water resources on the island and ensuring adequate supplies for use by residents. The Ministry of Health, Human Services, Family Affairs and Gender Relations is responsible for monitoring the quality of water in the rivers, especially those being used by the Water and Sewerage Authority and the water quality of intakes and treatment plants. The Departments of the Ministry of Agriculture, Forestry, Fisheries and the Environment (MAFFE) also conduct some water monitoring (for forest conservation and aquaculture development)."

Particularly detailed efforts and surveys have been made in the Falklands (Malvinas) as can be found at http://www.geog.ucl.ac.uk/ecrc/fibril/summary.htm

Quoting from that web-based report, the following observations are made:

"As far as can be inferred at present, the aquatic biota in the Falkland Island freshwater bodies are also in a fairly pristine condition. Although generally species poor, there are some unusual species present and several sites warrant special status. The Sulivan Lakes are already recognised but the Swan Inlets and Laguna Isla (East Falkland) and Hawk's Nest Pond (West Falkland) have considerable biological interest, not least concerning aquatic plants. The upland tarns are also unique ultra-oligotrophic habitats of note but these are unlikely to be affected by future land use changes. Threats to freshwater biodiversity in the Falkland Islands concern the following issues,

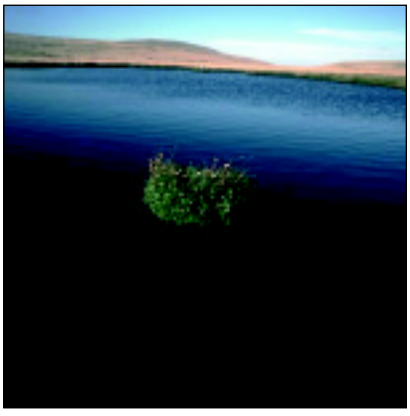
• Changes in landuse: these are perceived as likely to be mainly the continuation of long-term trends involving exploitation of grasslands. Plans to raise the quality of agricultural land through carbonate/nutrient additions could have future consequences for run-off water quality. Local effects of accelerated erosion through over grazing, grassland fires and road building should however also be considered.

• Climate: climate change is a global issue and although the ozone hole now includes the Falkland Islands there is no evidence that freshwater systems are affected on the Islands. However, without regular monitoring of the freshwater ecosystems initial effects may be unrecognised. Zooplankton in the clear water sites were heavily pigmented (a known response to high UV light levels) but we do not know if this is a recent or persistent condition. Sediment core analysis (in preparation) and on going in situ temperature monitoring may provide some information of climate trend effects on the upland tarns.

• Species introductions: the plight of the native trout (Aplochiton zebra) is relatively well known but this is not the case for other aquatic species. This study already indicates that a few diatom species are local (southern South American forms) but many are cosmopolitan and several may be new taxa. Detailed species information on aquatic invertebrates is not yet available but again without historical records recognising recent additions to the biota is difficult. Microfossil analysis of sediments is one way to detect such changes (results from the upland site sediment cores are in preparation)."

The initial results of this spatial survey involving a selection of freshwater bodies on the Falkland Islands indicate that all the investigated sites are in near pristine condition despite some problems with species introductions and local erosion. However without historical information (from sediment cores or from monitoring) current trends in aquatic ecosystem change cannot be assessed. The new EU Water Framework Directive for freshwaters stresses the need to undertake both chemical and biological assessment, through monitoring, as part of a wise management strategy for freshwaters. Together with the need to satisfy biodiversity responsibilities, it is recommended that the base-line

Maldives



information being made available by the 2001 survey is used in future evaluation comparisons by repeating the survey every ten years. Some regular annual monitoring of Falkland freshwaters, especially those of interest for fish and birds, should be instigated as soon as is convenient.

These observations, from the tropics and the sub-antarctic zones have remarkable similarity, and are echoed by many other island states. They emphasise that the biodiversity resources of Islands, characterized by high endemism and species richness, are under considerable threats. Detailed management strategies and plans must be prepared to ensure long-term viability of the freshwater ecosystems, and the water supplies they produce, protect and purify. Here is where the Ramsar Convention, working through its joint work programme with the Convention on Biological Diversity, can be most useful.

What can the ramsar convention contribute?

National Wetland Policies

National Wetland Policies are a useful way of expressing principles, stating intentions, showing what choices have been made about strategic directions, making commitments, facilitating and focusing consultation and consensus, expressing exhortations, and making roles and responsibilities clear. Being able to portray a national policy as delivering international commitments can be helpful in expediting its adoption and implementation, and in avoiding the re-invention of justifications for courses of action.

Whether a National Wetland Policy should be separate from other environmental policy will depend on the circumstances. It can be useful to look at every field of action through the lens of what is required for wetland objectives specifically, as codified under Ramsar, and to ensure a complete suite of actions is provided for. Specific wetland policies are also useful to create identification with, ownership of and engagement with the issues by those responsible. Policy and legislation should visibly and reasonably promptly be followed by 'real world' implementation and enforcement – if they are allowed to run too far ahead of what can be done in this regard, confidence in the process may be undermined.

The List Wetlands of International Importance

Upon joining the Ramsar Convention, each Contracting Party is obliged by Article 2.4 of the Convnetion to designate at least one wetland site for inclusion in the *List of Wetlands of International Importance.* Sites are selected by the Contracting Parties for designation under the Convention by reference to the Criteria for the Identification of Wetlands of International Importance. The Parties' designations are communicated to the Ramsar Bureau by means of a "Ramsar Information Sheet" which provides legal and scientific data on each site and is meant to be updated every six years. The new and updated data on Listed Sites is noted by the Bureau and copied to Wetlands International for inclusion in the Ramsar Sites.[2]

Afterword

It is clear that freshwater ecosystems on small islands echo the range of ecosystems on continental landmasses, but that they are subject to particular pressures from human and natural perturbations. Working together, the UN Secretariat and its agencies, key Conventions such as the Convention on Biological Diversity and the Ramsar Convention and key NGO's, can help small island nations and communities manage their freshwater ecosystems more effectively.

References

BENNETT, A.F. 2003. Linkages in the Landscape. (includes a CD-rom) Gland: IUCN

Useful urls:

http://www.biodiv.org/programmes/areas/water/

http://www.ramsar.org/

http://www.unesco.org/mab

http://whc.unesco.org/

[2] Database http://www.wetlands.org/RDB/Directory.html