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Reframing the fight against extinction

Despite the diversity of scientific disciplines represented by the IES membership, we are probably all united in ultimately working to ensure species and ecosystems avoid extinction.

The scale of our common 'enemy' is undeniably daunting: around one fifth of all vertebrate and plant life on Earth is currently threatened with extinction. This 'Holocene extinction', as it is known, is the sixth such mass event in our planet's biological history but the only one to have been caused by a single species. The pace at which the process is proceeding is also unprecedented: it is suggested that more species were lost between 1900 and 2000 than were in the millennia prior to this. By 2100, some scientists suggest that 50% of species will succumb to the threat and its, of course irreversible, impacts.

This is therefore a timely edition of the environmental scientist. Crucially though, it is also brave. Extinction is an epic and emotive topic; as such it would be easy to feature articles that do little more than reinforce a sense of futility or dread, reframe tired clichés around the ignominious demise of the dodo or simply serve to stimulate roving reminiscences about childhood fascinations with dinosaurs. But there is a desperate need to avoid this and instead provide new ideas and inspiration that fuel a refreshed sense of purpose and renew professional vigour, rigour and alacrity.

The authors of the articles that follow have thus attempted to rise to this challenge. They have strived to avoid Dante-esque diaries of despair and soapbox style lectures around moral imperatives to protect and promote biodiversity. As an illustrious suite of capable and committed environmental professionals, you are no doubt more aware of this than most.

Instead, their pieces aim to provide us with an inspiring array of powerful, insightful, enabling and compelling prose. They celebrate successes, share the tales and showcase the tools that might offer genuine solutions. This is with the hope that it will entice IES members to do what they can to take on humanity's greatest responsibility and challenge.

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Lethal Trade: Current extinction drivers

Richards Thomas provides an overview of the local and international conditions that are driving extinctions all over the globe.

Contemporary rates of extinction are alarming. The International Union for Conservation of Nature's (IUCN) Red List features almost 50,000 assessments of the extinction threat to species and publishes data to enable conservation action to be taken. Recent updates revealed that roughly one-fifth of all mammal, bird, amphibian, reptile and fish species are currently threatened (Table 1).

Stop someone in the street and ask 'what causes extinction?' and you are likely to get a wide divergence of answers. Some would probably list climate change – which has been dominating the environmental media for years – while a significant proportion would correctly identify habitat loss as the major driver of extinction in the world today. But how many would say over-exploitation by humankind?

Whilst not the most obvious threat to the world's wildlife, the impact of hunting and trade in animals and plants was recognised many years ago by one of the UK's best known and largest wildlife charities, the Royal Society for the Protection of Birds (RSPB). This organisation has its origins in late nineteenth century efforsts to curb the trade in birds feathers, used to adorn fashionable hats at the time. Such demand was not confined to Europe: on the other side of the continent, the short-tailed albatross, one of the most beautiful and elegant of the world's albatross species was hunted to near extinction for its feathers, but thanks to the seclusion of its last breeding site was able to survive the onslaught.

CURRENT PROBLEMS

Today, some 13% of the world's birds are under threat of extinction, and for many of these, trade is

▼ **Table 1: Estimates of percentage of threatened species (2001)**

Species	Best Estimate	Lowest Estimate	Highest Estimate
Cycads	63%	62%	64%
Amphibians	41%	30%	56%
Reef-forming corals	33%	27%	44%
Sharks & rays	31%	17%	63%
Freshwater crabs	31%	16%	65%
Conifers	30%	29%	33%
Mammals	25%	21%	36%
Groupers	18%	12%	43%
Birds	13%	12.5%	13%

Source: www.iucnredlist.org/about/summary-statistics [Accessed: Mar 2012]

a significant risk. Threatened birds range from the Maleo, whose huge buried egg is both easy to find and provides a wholesome food, to the crowned pigeons of New Guinea, who are pheasant-sized pigeons with a tasty meat. Many parrot species are targeted for the pet trade, and roughly speaking, the rarer, the more highly prized the bird.

In 2000, the last known wild Spix's macaw, a large blue parrot of the Brazilian interior died. Several dozen exist, but only in captivity. Another species that has disappeared from the wild is the Alagoas currasow – a turkey-like bird that was a victim of habitat loss and relentless poaching. The Socorro dove too is enduring the same ignominious end to its presence on the planet.

Trade itself may not be the direct cause of extinction threat to some birds. In the Southern Ocean boats trail massive longlines, some up to 100 miles long and baited with thousands upon thousands of hooks. Set to catch fish, these boats also attract scavengers: albatrosses and petrels. Tempted by the bait, they often swallow the hook, are pulled underwater and drown. Today all albatross species are threatened with extinction.

One notable extinction case is thought to be a result of the species in question being unable to compete for food with a self-introduced competitor: people. The eastern Canary Islands once held a thriving human population, who ate the mussels and other seashells found along the shoreline. However, as the numbers of people swelled, so did their consumption of molluscs, until there were simply insufficient left for either the people or the birds that also relied upon them for food. The Canary Islands black oystercatcher became extinct sometime in the mid twentieth century.

Current estimates compiled by IUCN consider a surprising third of the world's terrestrial animals as at risk through over-exploitation. Some are hunted for their meat, with wild animals providing the major source of protein for a growing population in many of the world's developing countries. For example, many Amazonian communities rely on subsistence hunting, which for generations has provided local people with the protein source and food they need to survive. However, this balance is easily undermined. A trend among nearby city dwellers to eat 'wild meat', coupled with the curiosity of tourists to try something exotic has led to overhunting and harvesting of the forest's natural resources, putting vulnerable species such as tapirs at risk. But helped by TRAFFIC and other Non-Governmental Organisations working in the region, local communities are fighting back. Local agreements not to supply the meat to cities and self-imposed curtailment of the hunting of those species most at risk have been combined with a restriction on hunting to allow other animal populations to recover.

In Central Africa, primates and other animals are the most significant source of local protein, and while their forests habitat may be plentiful in many areas, the animals that should be living there are not. 'Empty forest syndrome' is becoming a reality. TRAFFIC is leading efforts by governments in the region to find equitable solutions that ensure people do not go hungry and that the animals needed as a food source do not die out.

Offshore from land, we're doing little better. Every year an estimated 73 million sharks are killed for their fins. This wasteful and often cruel (the fins are sliced off and the live shark thrown back into the sea to drown) harvesting is having a devastating impact on the world's sharks. A third of oceanic shark species are considered at serious conservation risk and in danger of extinction, almost entirely because of overfishing. Breeding slowly and producing few young, they are prime candidates for being at risk of over-exploitation. And they're not alone; although fishery scientists unanimously agree that bluefin tuna are being fished to death, the world's governments repeatedly fail to take the necessary action to do anything to rectify the situation.

TRADE FOR NON-FOOD USES

Food is not the only reason animals are exploited to the extent where their very existence is on the line. The demand for animal parts can have other uses too: take shahtoosh, the fine wool of the Tibetan antelope used to make luxury shawls and other clothing items. Sadly it is quicker and easier to kill the antelope to shave its fur off and rampant poaching has seen Tibetan Antelope numbers plummet by half in twenty years. An analogous situation exists in South America, where the fine wool of the vicuna is highly prized, but here there is real conservation success and hope. Animals are rounded up, shaved and released unharmed. There is an added benefit too: the annual herding – or Chaco – has become a major event, helping bring tourists and their income to local people living in the impoverished Andean highlands.

Even more significant however is the demand of animals for use of their parts in medicine. There can be no more striking, nor perhaps sadder, example than the magnificent tiger. Certainly habitat loss has played a

"One false rumour had destroyed the Javan rhino in Vietnam, forever"

major part in the shrinking of wild tiger numbers from around 100,000 at the turn of the twentieth century to perhaps fewer than 4,000 today. Revered throughout much of its natural range, yet hunted to oblivion in many other parts. In large part this is due to demand for its parts – bones to be boiled down to make glue to be used in plasters, meat eaten to bestow strength, teeth and claws used as good luck charms, skin worn as clothing as a status symbol or a new fad of stewing the carcass to make tiger wine. All this despite trade in tigers being outlawed under national and international laws. Over a ten year period, research by TRAFFIC found that a minimum of 1,000 tigers, a staggering number, had quite literally been reduced to skin and bones.

Meanwhile the demand for animal parts can sometimes arise suddenly and unpredictably, with devastating impacts. Rhino horns are used in traditional Asian medicine as part of a concoction to treat high fever; the demand for horn from Asia for medicine, coupled with unregulated trophy hunting and demand for rhino horn to make decorative dagger handles in Yemen, caused the southern White rhino to be so relentlessly hunted that by the late nineteenth century it was thought to be extinct. Fortunately a few animals were rediscovered and, with careful nurturing and more than a century of protection, numbers of southern White rhinos recovered. Until the 1970s, when demand for their horns for use in traditional medicine once again soared. To compound this in 2007, a rumour began circulating in Vietnam that rhino horn could cure cancer. A senior Vietnamese politician was said to have cured himself of cancer using horn, despite his name and the circumstances of this cure never being revealed. It was as if the blue touch paper for horn demand had been lit. Suddenly rhino horn was the 'must have' substance to possess in Vietnam. The *nouveau rich* became keen to impress their peers by showing off their wealth by buying the new miracle cure or giving it as a gift. Rhino horn was even supposed to be an antidote to the high life – an expensive, and medically unproven hangover cure. Criminals would do anything to get their hands on it to sell on at huge prices. Rhino poaching rose rapidly in South Africa – from a dozen or so animals illegally killed there in 2007 to almost 450 in 2011 alone. Meanwhile, across Europe, a criminal gang has targeted museums and other collections where antique rhino horns were held. In Vietnam itself, the last Javan rhino, the mainland relic of a species that once roamed across the Asian mainland to the island of Java, was slaughtered. A post-mortem found it had been shot and its horn removed. One false rumour had destroyed the Javan rhino in Vietnam, forever. Slowly the world's rhinos are being butchered. And the international trade ban, which is still in place, is not proving a deterrent. Why? Because disposable income is increasing in some Asian countries and if you pay enough, you can buy whatever you want. Someone, somewhere will take the risk to get it for you. Humankind's greed is fuelling the extinction crisis.

"Humankind's greed is fuelling the extinction crisis"

But while over-exploitation for trade in animals might be overlooked as posing a serious extinction risk, what about the risk posed by trade in plants? Of the 34,000 plant and animal species listed in CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), some 29,000 are plants. Trade in plants takes place for a variety of reasons – from orchids, illegally taken from the wild for specialist growers, to plants utilised by many of the world's poorest people as their basis for medicinal treatments. Overharvesting of plant resources can quickly lead to loss. In South Africa, native cycads – bread palms or bread trees – are under immense pressure through over-collection for the horticultural trade. The country is a global hotspot for cycads, but 31% of the country's species are classified as Critically Endangered; that is, facing an extremely high risk of extinction in the wild in the immediate future. Four of them have already disappeared from the wild. So trade is unquestionably a major driver of extinction across all forms of life.

It is not all doom and gloom. History shows us we do have the capacity to put right what we first made wrong: as the case of the southern White rhino shows, we can restore wildlife populations. Whale numbers are recovering in the world's oceans, after decades of overharvesting. Trade in wild animals and plants, needs to be held at sustainable levels which does not put them at risk of extinction. This concept is the very core of our being and reason. It is also common sense: if trade is not brought within sustainable limits, vital resources will be lost and the planet as a whole will be a poorer place. ES

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What happens when nature is lost?

The negative legacy for future generations of humankind resulting from species extinction is discussed by **Mark Everard**.

Moral imperatives about society's contribution to accelerated extinction stem both from the inherent value of the organisms and their bequest to future generations. Every species, every locally-adapted strain, carries 3.85 billion years of genetic heritage, integration with other organisms with which they have co-evolved, capacity to adapt to changing environments, and hence resilience.

There are also many more consequences stemming from extinction. The pace at which some manifest can make them appear less pressing than today's economic and other political priorities, but humankind overlooks the impacts of its pathway of development upon the other species with which it shares this Earth at its considerable peril. Extinction is, after all, irreversible and forever.

WHAT NATURE DOES

It is important to consider the moral and ethical dimensions of humankind's relationship with species and habitats, but it is also vital to recognise the direct and visceral nature of its connections to them. People eat, breathe and drink them, and use them as resources for furniture and construction products, and as the inputs of paper, energy and ink in office machinery. They are used to clean up waste, and society hunts and walks within them. They define the character of towns and aesthetically-valued places, inspiring and calming people, and they may even add to property values. Nature, without fear of overstatement, makes life possible, as well as providing economic resources and enhancing people's quality of life.

This is what 'ecosystem services' are all about: the many things that nature does that benefit people. The harmonisation of disparate pre-existing biogeographical and habitat-specific classification schemes under the UN Millennium Ecosystem Services (MA)[1] grouped ecosystem services into the four broad categories of: 'provisioning'; 'regulatory'; 'cultural'; and 'supporting' services. Importantly, the MA ecosystem services framework integrates not only the many things that species and ecosystems do, but also the diverse people who benefit from them together with their different value systems.

Quite apart from the moral imperative every extinction (globally or locally) is a break in the 'web of life' supporting the diverse interests of all people, significantly including those as yet unborn. For this reason, it is valuable to consider the importance of species through the 'lens' of ecosystem services to broaden appreciation of the potential impacts of extinction.

A FRESHWATER EXAMPLE

Freshwater fish provide a useful example as a group of animals threatened by extinction at global scale. The MA Ecosystems and Human Well-being: Wetlands and Water Synthesis report[2] summarises the many beneficial services that the world's freshwater ecosystems provide. It also documents that the degradation of wetlands and freshwater species is more rapid than for other major global habitat types, noting that "Approximately 20% of the world's 10,000 described

Coastal Fish Farm

freshwater fish species have been listed as threatened, endangered, or extinct in the last few decades". Of European freshwater fish species, 38% (200 of 522) are also threatened with extinction and a further 12 are already extinct, representing a greater threat than for Europe's birds or mammals[3].

Freshwater fish populations thus serve as a primary indicator of the vulnerability of freshwater systems, reflecting their extraordinary vulnerability to the cumulative impacts of a range of human pressures, from land use and effluent discharges to climate change and habitat modification. For this reason, it is instructive to apply what is known about ecosystem services to explore the consequences for the breadth of human interests of the loss of species and genetically-distinct local strains of freshwater fish.

BENEFICIAL SERVICES

The provisioning ecosystem services comprise tangible 'goods' that can be extracted from ecosystems, for example food. Fish, both marine and freshwater, account for roughly one-fifth of all animal protein consumed by humans across the world. Fishery and aquaculture activities providing this resource are significant for global employment. There are feedbacks here, in that over-fishing and insensitive aquaculture are also major pressures on fish stocks. Additional benefits also flow from the use and trade in stock and ornamental fish, and for a wide range of other purposes such as feed for farmed stock, use as fertilizer, extraction of substances such as oils and isinglass, and products used as ornamental resources[4]. The genetic heritage of some wild species and strains is also used to breed valued traits into farmed and ornamental stock, boosting their resilience and utility.

Fish also play direct and indirect roles in regulatory ecosystem services. Species such as guppies (*Poecilia reticulata*) and a range of others generically known as 'mosquito fish' (particularly *Gambusia affinis*) are widely introduced across the tropics for the control of the mosquito vectors of malaria, though their efficacy is contested. However, fish are also themselves vectors of a variety of parasites affecting both wildlife and, in some cases, humans.

Fish can also influence erosion regulation as well as physico-chemical purification processes. For example when sediment-grubbing species (such as the common carp, *Cyprinus carpio*) are introduced beyond the

"For all humankind's technological sophistication, species and their interactions are the warp and weft of the fabric of life supporting all dimensions of humanity"

geographical range in which they evolved they are implicated in significant ecosystem change, including: exacerbated erosion and release of nutrients; declining physico-chemical purification processes; and wider disruption or displacement of native ecosystems and their processes. This can be seen in examples across all continents.

Fish populations also have a significant indirect influence on the regulation of water quality; their chemical quality requirements underpin many technical management standards such as those found in domestic and EU legislation, resulting in the innovation of technologies and prioritisation of investment in water quality regulation. Consequences for fish and fisheries have also seen the development of a rich case law under common law, since both can legally constitute 'property'[5].

Fish play significant and diverse roles in terms of cultural ecosystem services. Recreational freshwater fisheries are perhaps the most obvious and readily-valued of these, with a range of substantial published estimates of value of angling to the UK economy[6,7,8,9]. However, the cultural value of freshwater fish substantially exceeds angling, as they also provide important educational and research subjects and are used as living monitors in water intakes to major US cities as a counter-terrorism measure[4].

Freshwater fishes are valued directly for their nature conservation importance, many scheduled in global accords such as the IUCN Red Data Book, supranational legislation including for example the EU Habitats Directive, and in national regulations and frameworks such as the Wildlife and Countryside Act 1981 and the UK Biodiversity Action Plan. Fish can also serve indirectly in attracting substantial ecotourism markets, potentially exceeding the regional economic value of agricultural production in some parts of the UK[10], as well as contributing sometimes substantially to international ecotourism[11].

Additional valued cultural ecosystem services relating to fish include their role in connecting people with nature, for example through their presence not only in the specialist press and many books, but also popular broadcast media such as radio and television, in art, music such as Franz Schubert's *lied* 'Die Forelle' (The Trout) and many popular songs, and in literature including as an example Henry Williamson's classic book Salar the Salmon. Furthermore, bodies such as angling, wildlife and pet fishkeeping associations can generate social capital, with angling in particular playing an acknowledged significant role in social inclusion[12]. Fish can define the whole economy and culture of some peoples, as dramatically illustrated by the massive reparations won in 1978 in the legal

The golden mahseer (*Tor putitora*), a vulnerable fish species from the Himalayan headwaters of the Ganges River system in India
Source: Mark Everard

case filed by the Colville Confederated Tribes against the United States government for damages stemming from the Grand Coolee Dam, settled after 27 years with US$66 million as historic compensation and annual payments of US$15 million to offset ongoing reduced income opportunities.

Even in less directly natural resource-dependent cultures, symbolic fish can represent a focal point for public mobilisation around environmental causes. For example, the long-term and ambitious vision of salmon returning to the Thames system garnered the support of wide constituencies of society in the setting up in 1986 of the Thames Salmon Trust, reconstituted in 2005 as the Thames Rivers Restoration Trust. Fish were also a visible and publicly-valued indicator of other major river rehabilitation schemes such as the Mersey Basin Campaign[13]. Indeed, restored and attractive waterfronts capable once again of supporting thriving fish stocks can add substantially to riverside domestic and commercial property values[14].

The supporting ecosystem services are often less immediately visible, defining internal ecosystem functions essential for maintaining ecosystem functioning and resilience. Different species of freshwater fishes play important roles at all trophic

"Society loses potential economic resources, cultural assets, links in important ecosystem processes...people's lives are not only impoverished, but also imperilled"

levels, maintaining ecosystem connectivity and functioning including the cycling of nutrients.

IF FISH ARE LOST?

The extinction of fish, whether species loss or the extirpation of locally-adapted stock, is detrimental to all ecosystem services. Society loses potential economic resources, cultural assets, links in important ecosystem processes, and bequests to future generations. In short, people's lives are not only impoverished, but also imperilled.

For all humankind's technological sophistication, species and their interactions are the warp and weft of the fabric of life supporting all dimensions of humanity. It is possible to lose some threads and, owing to the adaptive capacity evolved into ecosystems through billions of years of evolution, still believe that the supporting foundations remain robust. However, there are numerous examples of catastrophic failures and ensuing human misery as 'tipping points' are reached, including for example collapses of fisheries after sustained over-harvesting, degradation of water resources through continued pollution and/or habitat modification, and serious consequences for pollination services long assumed as 'for free' as honey bee populations crash. However these spectacular collapses are, in fact, merely the more dramatic 'tips of the iceberg' of incremental extinction. Unseen and largely unappreciated, systematic degradation of genetic diversity within species and local losses of organisms together with tight interactions with others evolved over long timescales may be far more insidious.

The very fact that 20% of the world's freshwater fish are categorised as threatened, endangered or extinct, or that 38% of European freshwater fish species are threatened with a further 12 already extinct, provides a graphic illustration of the extent to which that supporting fabric of nature is already seriously, perhaps irreversibly degraded.

The diverse value systems encoded in the MA ecosystem services classification should warn of the parlous ethical, economic, health and other dimensions of this alarming trend. Freshwater fish then are far from a luxury, there for the enjoyment of anglers and wildlife enthusiasts but not material to the constraint of economic progress. Rather, they are amongst the most direct and sensitive 'barometers' of the vitality of ecosystems essential for continued wellbeing. Their fate, and humankind's, are not merely linked but conjoined. Society will permit the continued rate of extinction of freshwater fishes, indeed of all species, at its own considerable moral, economic and mortal peril. ES

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Species level extinction: the wolf

Gayle Burgess traces man's historical demonization and destruction of the wolf, followed recently by attempts to reintroduce the species into parts of the USA and Scotland.

It could be argued that until approximately the middle of the last century, the pace of human 'progress' was such that typically, single species were individually extirpated from the ecosystems humankind sought to 'settle'. While the extinction rate overall was greater than it had been for many millions of years, local and national level extinctions were typically more common than global extinctions and the total loss of species. Alarmingly, history reveals that rather than representing a significant cause for concern, such processes reflected the primary ambition of our pseudo-heroic endeavours to 'tame' the tumultuous wilds.

Targeted species tended to be top-level predators or mega-fauna perceived to be a 'threat' in some way. The threat could either be direct (through conflict or diseases such as rabies) or indirect (through predation on livestock or destruction of crops). Few species experienced such persistent and focused attempts at their eradication as the wolf (*Canis lupus*).

US-based naturalist Barry Lopez made a breathtaking attempt to catalogue wolf biology, place in society's cultural history and centuries of demonisation and destruction, through his landmark book '*Of Wolves and Men*' (1978). Few publications have in the last 40 years laid-bare so utterly humanity's ability to literally 'hate' another animal to the edge of existence.

Lopez describes humankind's efforts to exterminate the wolf as nothing short of a holocaust. Once regarded as the world's most widespread mammal, between 1600 and 1950 wolves became extinct across much of Western Europe, Mexico and the lower 48, or contiguous, United States. Wolf extirpations were a cause célèbre throughout ecosystems on each continent. The last British wolf was reportedly killed in Moray, Scotland in 1743. It has been estimated that up to two million were culled in the colonisation of North America through the campaign waged against the so-called 'beast of waste and desolation'. Millions more animals became collateral damage – antelope, deer, ferrets, skunks, badgers, weasels, wolverines, bears, eagles, red-tailed hawks and ravens were common casualties, dying painfully and indiscriminately in wolf traps, bait poisoned with strychnine, arsenic and cyanide, or even by eating the grass where wolves had foamed at the mouth as they died.

As humanity entered more 'enlightened' times preventing species-level extinction, and reversing it through reintroduction programmes, became a worthwhile cause wholeheartedly agreed upon by both conservation professionals and the general public alike. There has however remained a persistent divergence of opinion around 'point' and 'process' with the wolf. A groundswell of 'not in my backyard' responses is reported any time wolf reintroductions are raised. While this could be the relic of centuries' old antipathies common across continental divides, how representative are such opinions? Do they arise from a legitimate scientific truth or simply a powerful perception that has not eroded with ages? Should such attitudes be allowed to put off a process that could restore ecological integrity and a natural balance to many imbalanced montane, alpine and sub-arctic ecosystems across Europe and North America? Two reintroduction programmes allow reflection on these issues.

YELLOWSTONE

After a 70 year absence, between 1995 and 1997 a total of 31 grey wolves (mainly *C. lupus irremotus*) captured from different packs across Canada were reintroduced to the Yellowstone National Park and Central Idaho[1].

Shortly after release, the animals formed four packs and established territories across the subarctic, alpine and subalpine environments within, and just outside, the north-eastern reaches of America's first National Park.

One rationale for the Yellowstone reintroduction was to reduce the number of ungulates which, by virtue of volume alone, were damaging floral species density, health and biodiversity in and around the Park. Initially, elk formed 90% of wolf prey, but the animal's Canadian pedigree suggested they would help curtail the burgeoning bison population. In 2010 the 97 grey wolves (11 packs, 6 loners) in Yellowstone were still preying primarily on elk (80%) but also on bison (10%). An opportunistic mix was revealed to the rest, with deer, moose, pronghorn antelope, coyotes, ravens and bears all apparent in kills[2]. The improved prospects of a variety of woody plant species, such as riparian cottonwoods (*Populus spp.*) and willows (*Salix spp.*), were attributed to this prey profile accordingly[3].

The controversy over the reintroduction in Yellowstone came primarily from ranchers concerned about losing cattle as prey. Wolf no. 27 (of the original 31) seemed an especially destructive individual and fuelled this fear when he killed approximately 50 sheep owned by one rancher. He was subsequently destroyed and the farmer compensated by a pro-wolf charity. Except for this, local livestock sustained little damage, which aligned well with US Fish and Wildlife Service (USFWS) Environmental Impact Statement forecasts[1].

The USFWS showed courage and leadership in entreating a measured reaction throughout: when asked about the impact wolves were having on free-ranging ranch animals, spokesperson Ed Bangs told CNN: "On average, wolves kill about four or five [cattle] a year, so... wolf predation means nothing to the industry or the economy of this area. Some ranchers say, 'Look, its people or wolves, not both' – I think we're at point now with wildlife and biodiversity and conservation biology in the United States that we can do better. It's not black or white. We can have both.[4]"

This federal-level endorsement helped ensure a strong focus on the science over people's fears, and thereby, the success of the programme overall. Since the first wolf was released, scientific evidence indicates the programme has generated significant environmental benefits and arguably economic ones too. In addition to enhancing the floral biodiversity and plant health[3], wolf reintroduction also facilitated increased scavenging by species such as coyotes, foxes and ravens[5]. Tourism is abounding too, with 14.5 million visitors to the park annually.

Would such success be replicated on a smaller scale in Scotland?

Cottonwood in Yellowstone

"Those responsible for ecosystem management in the UK should observe the influential role played by strong leadership and courage"

GLEN AFFRIC AND ALLADALE

A reintroduction programme in the Highlands of Scotland has been considered since the 1960s but not yet realised. High profile research attempting to bring a neutral and rational perspective[6] predicted that reintroducing wolves to land they last roamed in the 1700s would bring important economic benefits to an otherwise depressed area and be welcomed by the public.

Economic benefits arise from high red deer (*Cervus elaphus*) densities across release areas. To reduce the extensive ecological damage caused through overgrazing[7], the Deer Commission for Scotland (DCfS) has to maintain an annual cull, despite the relatively low fecundity of the species (one calf per hind every other year). Hinds are consequently shot by rangers (which costs money), while stags tend to be shot by trophy hunters (which makes money). Sophisticated modelling predicts that following a reintroduction of wolves, Highland estates currently conducting this cull could consequently expect to; "make £800 a year per 10km^2 from culling 40% of stags

and not hinds, while without wolves it would make £550 a year per 10km², from culling 40% of stags and 11% of hinds" (the 11% being required in order to meet DCfS' density requirements).

Surveying public receptiveness to *C. lupus* reintroduction revealed that both urban and rural respondents were positive about the idea; "43% of respondents favoured reintroduction of a range of species, including wolves into the wild; 35% favoured reintroductions into fenced eco-parks… [and in] the rural population, 23% felt that deer control was the major advantage of wolf reintroductions, with the potential for tourism ranking second (21% of respondents)".

MFI heir Sir Paul Lister has attempted a range of re-wilding initiatives on the Alladale Estate, Scotland, which he procured for the purpose in 2003. His powerful personal vision for the 23,000 acre site, northwest of Inverness, was to restore some of the endemic animals that once roamed the forest ecosystems there but are now nationally extinct. The initiative enjoyed success with 'benign' species such as European elk (*Alces alces*) and wild boar (*Sus scrofa*), and was strangely reinforced when white tailed sea eagles (*Haliaeetus albicilla*) migrated in from reintroduction programmes elsewhere. Following this, plans now proceed apace with species such as European bison (*Bison bonasus*) and beaver (*Castor fiber*). Attempts to introduce four Romanian wolves (*C. lupus lupus*) however, have stirred up significant controversy and encountered several challenges.

When Alladale's licence to keep dangerous wild animals was renewed by Caithness, Sutherland and Easter Ross Council in 2010, Mr Lister and his team were hoping to realise an ambition that would encompass not only all of their estate but also elements of neighbouring estates. Feasibility analysis identified that 50,000 acres would be required to sustain a healthy population (two packs) of wolves. This unfortunately led to a contentious and critical apex: the 50,000 acres would need to be fenced in. While Alladale neighbours might have been amenable, a surprising array of outdoor enthusiasts was vocally not. Fences contravene 'Right to Roam' legislation in an area where this is big business; hillwalking and mountaineering are critical to the Highland economy and the Ramblers, the Mountaineering Council of Scotland and Council Access Officers received high profile coverage when they expressed their concerns. Tragically, this effectively stopped what would have been a pioneering and pivotal step forward towards harmonising an imperilled highland ecology.

LESSONS LEARNED?

There is probably truth to the argument that the Yellowstone reintroduction worked simply because there was 'more space' for wolves. There is, however, another side to the story that should not be overlooked. Those responsible for ecosystem management in the UK should observe the influential role played by strong leadership and courage. Science shows that reintroducing species lost through local and national level extinctions is an effective way to restore ecological integrity and a natural balance to the many currently imbalanced ecosystems around the world; case studies complement this in suggesting other 'win-win' benefits for wilderness areas. However brief analysis indicates that such evidence must be employed to underpin a compelling vision communicated with conviction, before humankind can expect to restore our diminished natural history and ultimately therefore compromised cultural identity. ES

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Opportunity costs in the pharmaceutical sector

Annelisa Grigg considers the value of biodiversity to the pharmaceutical sector and the implication of biodiversity loss.

Brazilian rainforest
Photo credit: Stuart Butchart

The *Economics of Ecosystems and Biodiversity*, commissioned by The Environment Ministers of the G8 and five major developing countries, estimated that between a quarter and a half of the whole pharmaceutical market is derived from genetic resources[1]. This suggests a significant economic interdependency between pharmaceutical research, development pipelines and biodiversity.

BIODIVERSE MEDICINES

Many of the world's major medicines are indirectly derived from biodiversity. Nearly half of all cancer drugs approved by the USA Food and Drug Administration between the 1940s and 2010 were developed from natural products or derivatives of natural products[2]. In 2002, 42 per cent of the sales of the world's top-selling 25 drugs were either obtained directly from or derived from natural products[3]. Indeed, many of the drugs with which people are familiar are derived from natural products. Aspirin, for example, was originally derived from willow bark. Taxol, used in cancer treatment was derived from the yew tree. Although some 35,000 – 70,000 species are used medicinally worldwide, only a fraction of these have been used in drug development[4].

A number of plants and animals that are known to hold significant opportunities for medical research are threatened with extinction. Bears, for example, neither lose bone mass nor excrete urine whilst hibernating. Studying this ability could potentially provide insights into osteoporosis and means of combating renal failure. Six of the eight bear species are listed in the International Union for Conservation of Nature's 2011 Red List as threatened with extinction. The southern gastric brooding frog went extinct before researchers could investigate the properties of the substance it used to inhibit acid and enzyme secretions and protect its young which were raised in its stomach. It could have offered relief to millions of sufferers of peptic ulcers[5].

A CHANGE IN FOCUS

The industry's focus on natural products has changed. Many of the statistics quoted above pre-date a shift in technology and in the industry which has led to a decline in reliance on natural products[6]. With the development of new chemical techniques and rapid

screening processes, existing molecular libraries form the basis of drug discovery rather than traditional knowledge of medicines or 'bioprospecting' (the process of looking for potentially valuable genetic resources and biochemical compounds in nature)[7]. Furthermore, natural product based drug discovery itself has been shown to be challenging, with long lead times, low returns and challenges in creating synthetic versions of natural active ingredients.

CURRENT PHARMACEUTICAL USE

Several corporate natural product discovery programmes have now been scaled down or closed (for example, Abbott, GlaxoSmithKline and Shaman Pharmaceuticals[8]) with many of these closures happening in the early 2000s. Despite these closures and a focus for the last twenty years on combinatorial chemistry (rapid synthesis or the computer simulation of a large number of different but structurally related molecules or materials), a recent US based study revealed that natural products still play a significant part in the global pharmaceuticals market[9] (see Figure 1). Furthermore, in 2008 over 100 compounds derived from natural products were undergoing clinical trials and at least 100 similar projects were in preclinical development10. A review of the top 40 pharmaceutical companies showed active natural product discovery programmes remained in Eisai, Novartis, and Sanofi with some evidence of limited activity within Astellas, Bayer, BMS, Genzyme, Pfizer, Mylan and Takeda.

A SOURCE OF INNOVATION

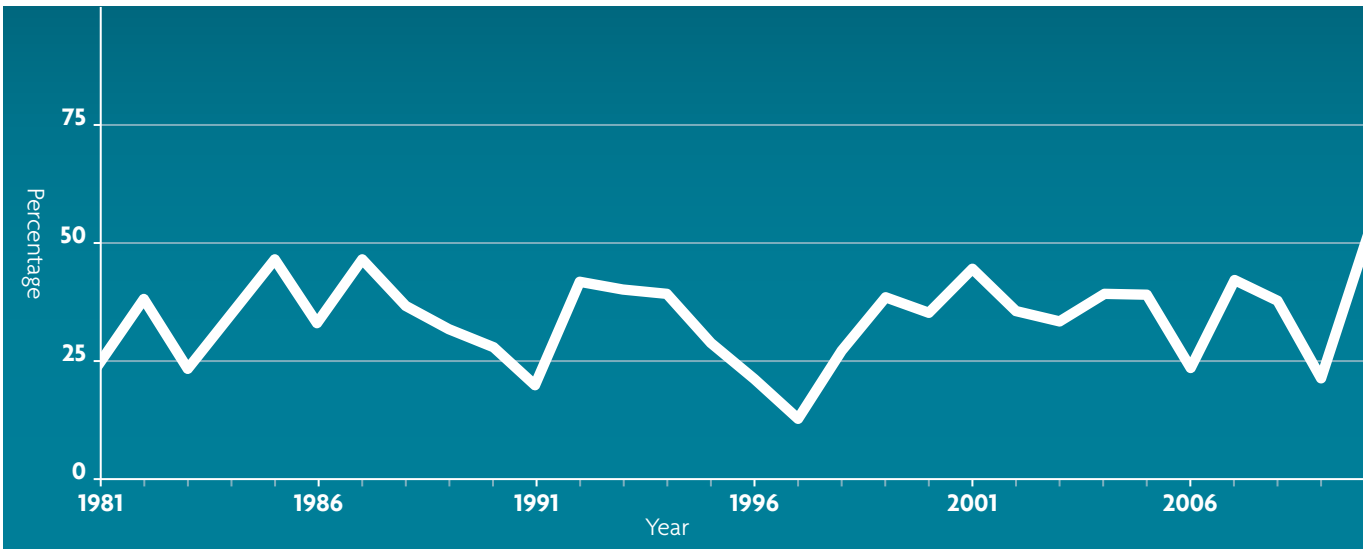
Those companies still undertaking natural product based drug discovery believe that this provides them with a competitive advantage. Natural products such as penicillin or cyclosporine may be so structurally unique and subtle that no chemist would ever synthesize them under laboratory conditions. Furthermore, studying natural substances has provided insights into disease-related pathways that open up further opportunities for drug discovery[11].

Comparisons of the chemical properties of collections of natural products show that they are more closely aligned to the 'chemical space' of successful drugs than collections of synthetic chemicals[12]. Of the 13 natural product-related drugs approved from 2005 to 2007, five represented the first members of new classes of drugs[13]. This suggests that a focus on natural product based drugs still offers the industry opportunities for greater innovation.

FUTURE REVIVAL?

One of the barriers to companies engaging in natural product discovery has been the lack of national-level legal certainty about securing access to genetic resources and equitably sharing the benefits derived from them. Failure to secure consent to access genetic resources, or to ensure that benefits derived from the natural products flow to the traditional 'owners' of those natural resources (such as local communities and local governments) posed a significant reputational risk to pharmaceutical companies. It has led to accusations of biopiracy and withdrawal of patents, and resulted in lengthy and costly negotiations to secure access to new materials, or loss of future revenue flows if patents are refused[14]. For example, Schwabe Pharmaceuticals' patent application for its phytopharmaceutical Umckaloabo which is extracted from the root of South Africa's *Pelargonium sidoides* was challenged for failing to meet requirements set by the Convention on Biological Diversity (CBD) for access and benefit sharing – having been used for many years as a traditional remedy in South Africa[15].

▼ **Figure 1: the percentage of new drugs developed from natural products or derivatives of natural products over the past 30 years.[9]**



Fern in Papua New Guinea
Photo credit: Stuart Butchart

"Is the current rapid, unprecedented decline of biodiversity going to rob society of the new aspirin, or the cure for cancer or HIV Aids?"

The new *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization*, agreed at the 10th conference of the Parties of the CBD in 2010, offers hope for greater clarity at a national level. It requires the establishment of appropriate national legal frameworks, and in doing so will reduce the reputational and regulatory risks associated with bioprospecting.

A number of countries are taking steps to catalogue the value of natural products within their borders, with the specific aim of building biotechnology and drug discovery capabilities. Colombia, for example, has made a policy commitment to develop a national company for bioprospecting which will link to the commercial sector and which is underwritten by government funds[16].

Natural product based drug discovery has become more economically feasible as a result of rapid screening and synthetic molecule production[17]. The pressure for innovation and more robust pharmaceutical pipelines is growing. This pressure, combined with a greater clarity on the legal framework for bioprospecting, might encourage a resurgence in bioprospecting, thus increasing the potential economic value of biodiversity to the pharmaceutical sector.

FAR-REACHING HEALTH BENEFITS

The links between biodiversity, ecosystems and human health go far beyond just the production of natural product based drugs[18]. Studies have shown that in areas of extreme poverty, where ecosystem services such as access to fresh water, to healthy soils or pollinators are compromised, so too is human health. Poor nutrition, caused by increasingly degraded ecosystems, goes hand in hand with high rates of illness and disease. Furthermore, evidence is mounting that patterns of disease will be significantly shifted by the world's changing biodiversity[19].

COSTS ON SOCIETY

The bulk of the costs of biodiversity loss may fall on society, not industry. Is the current rapid, unprecedented decline of biodiversity- the sixth mass extinction – going to rob society of the new aspirin, or the cure for cancer or HIV Aids? Quite possibly. Will it hit the bottom line of the pharmaceutical sector? Perhaps not in the short term, but falling rates of innovation and a loss of access to novel medicines may result in unforeseen opportunity costs for the sector in the medium term.

A study by KPMG, investor Robeco and international environmental non-governmental organisation, Fauna & Flora International, highlighted a range of risks (financial, regulatory and market) and opportunities

(such as new product development) that are emerging for the industry linked to loss of biodiversity and ecosystem services[20].

However, the greatest costs are likely to be experienced by society as a result of the impacts of changing patterns of disease, loss of access to clean drinking water and food and loss of sources of traditional medicines. These costs will be felt first by the world's poorest. Approximately 80% of people in developing countries rely on traditional medicines, the majority of which are derived from plants. Many medicinal plants are at risk of extinction, particularly in those locations where people are most dependent on them for health care and income[21].

ACTION REQUIRED

Increasing the motivation of the pharmaceutical industry to value biodiversity and the active ingredients derived from it for drug production will help provide a greater economic incentive to conserve biodiversity. Incentives could include demonstration of the links between product innovation and natural product based drug discovery, underwriting of elements of the bioprospecting process (for example in countries such as Brazil, Colombia and Kenya) and improved clarity on national legislation for access and benefit sharing through ratification and implementation of the Nagoya Protocol. Such incentives are essential to extract the value of nature to drug discovery and to help secure human health into the future. Without them, it is estimated that, at current plant and animal extinction rate, one major drug will be lost every two years[22], a valuable opportunity lost. ES

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Preventing local extinctions in aquatic habitats

Bryony Townhill and **Celia Figueira** discuss mechanisms for preventing local extinctions caused by aquatic habitat loss.

For centuries habitat loss has caused local and total extinction of aquatic species with huge areas of fens, marshes, rivers and lakes being lost. This is still continuing today in the UK with low flows and pollution being major causes of habitat degradation. However, with new legislation and long-term planning, there is hope for remaining water life.

Aquatic habitats are very varied and support and wide range of species, and so it is no surprise that loss of habitats can lead to localised or sometimes entire species extinction. When freshwater habitats such as lakes, rivers, marshes and fens are lost or degraded, wide-ranging or mobile species of birds, fish and mammals can move to other areas where available, whereas macroinvertebrates, aquatic plants and some fish are not able to move away and so will inevitably die. For all of these species however, when the habitat in that area is lost they will become locally extinct potentially affecting whole ecosystems. In the last decade, aquatic habitats have been lost for a variety of reasons. Information available on the UK's Biodiversity Action Reporting System gives some recent examples. In Lincolnshire, ten hectares of reedbeds have been drained for flood defence, in Neath, Port Talbot, riparian habitat has been infilled for development and ten kilometres of the River Dee have been degraded due to abstraction and modification[1]. All habitat losses such as these have the potential to cause local extinctions.

Historically large areas of fen and marsh in the UK were drained for agriculture causing whole landscapes to change and removing habitat for numerous aquatic plants and animals. It is hard to imagine the expanse of reedbeds and open water that once covered parts of East Anglia, acting as home to bird species which are now beginning to return to nature reserves and The Broads. Bittern, marsh harriers, cranes and many other birds and 'less endearing' animals and plants that were once so numerous are now beginning to return thanks to habitat creation and reintroduction programmes.

THE UK SITUATION

Current pressures on freshwater habitats include development, pollution and abstraction for agricultural, industrial and domestic use. Population increase in the UK puts huge pressures on water resources and this is only likely to increase with climate change as summers become hotter and drier. In December 2011, the Department for Environment, Food and Rural

Affairs (Defra) published its Water White Paper[2] which describes the UK's challenge to balance water availability and need. The White Paper states that, due in part to abstraction (taking water from its source), only 27% of the UK's rivers and lakes are fully functioning ecosystems. With water demand predicted to rise by 35% by 2050, pressure on freshwater habitats is set to increase. Climate change is predicted to create a higher water demand as temperatures rise and also to increase evaporation from rivers and lakes, putting more pressure on available waters.

A number of freshwater habitats including reedbeds, lowland fens and lakes are listed on the UK's Biodiversity Action Plan. In addition, many aquatic habitats are protected as nature reserves or designated sites. While these give some protection from human activities, any negative effects of climate change are not as easy to reduce. Despite overabstracting in places, the water industry has also had positive impacts on aquatic habitats, with many reservoirs around the country declared protected areas, often due to the bird populations they support. This gives good protection to the ecosystem as a whole and managers of these waters are required to maintain their condition. The case study of Rutland Water reservoir shows how work by a water company and conservation organisation, and obligations under the Habitats Regulations, can improve aquatic habitats and the numbers and diversity of species they support. However, the government is carrying out a review of the Habitats Regulations and there is much concern in nature conservation circles that in the future protection of designated sites may be reduced.

In the last ten years, work has been carried out to try to reduce the impact of abstractions. The Environment Agency has carried out a Review of Consents (permissions to control emissions to air, land and water) for all areas protected under the Habitats Regulations. Changes have been made to thousands of consents to improve the condition of these areas. The Agency is now rolling out the programme to Sites of Special Scientific Interest to identify those that are degraded due to excessive water abstraction. The Restoring Sustainable Abstraction programme aims to find out where there are problems caused by abstraction licences and to work with water companies to reduce these. Funding is available to benefit more than 1100 miles of river and 200 square miles of wetlands, while the Environment Agency announced in January 2012 that more than 590 miles river in the UK have already had their flows restored[3].

In addition to looking at specific areas, the government wants to overhaul the abstraction system and also the way water is used to improve the state of our aquatic ecosystems. Water companies are updating their drought plans which describe how water will be managed during a drought, taking into account the need for abstractions and environmental concerns. The Water Framework Directive requires aquatic habitats to be improved within Europe with pollution being reduced and barriers to migration removed. The hope is that all of the work being done by government, water companies and landowners to improve freshwater habitats will prevent the degradation of these habitats and the loss of species.

RUTLAND WATER

Recent works at Rutland Water Reservoir in the east of England are a good example of how water demand can be sustainably managed to have positive effects on wildlife. Anglian Water Service's Rutland Water Reservoir is jointly managed by the Leicestershire and Rutland Wildlife Trust as a nature reserve. Rutland Water is manmade but is internationally designated as a Ramsar site (a designated wetlands site of international importance) and a Special Protection Area under the Habitats Regulations, because its lagoon habitats support important wildfowl populations, particularly the gadwall and shoveler birds. The lagoons provide ideal habitats for gadwall which require shallow standing water with emergent vegetation and islands, and shoveler which require very shallow, permanent and productive waters. Feeding on aquatic plants, small fish and aquatic invertebrates, both species find much food in the reservoir.

An increase in water demand in the Anglian region means that Anglian Water Services need to abstract more water from the reservoir, consequently reducing the water level during low flow conditions. This reduction in water levels could affect the wildfowl populations in the reservoir, with the potential to cause local extinctions. To prevent this and maintain Rutland Water's designated status and meet its conservation objectives, eight new lagoons have been created to

"It is hard to imagine the expanse of reedbeds and open water that once covered parts of East Anglia, acting as home to bird species which are now beginning to return to nature reserves and The Broads"

ensure that suitable habitat and conditions exist to support displaced wildfowl. The lagoons were built between 2009 and 2010 and monitoring is being carried out to follow the colonisation process of the new lagoons, and to assess whether the lagoons are suitable for wildfowl.

The new lagoons were designed to be similar in depth and area profile and to provide a range of habitats suitable for different bird species. The lagoons have very shallow areas and islands which provide shelter, roosting and feeding areas for moulting and overwintering birds. The lagoons were made by either creating embankments or by impounding which prevents shallow water from drying out at very low water levels. No vegetation was planted and the lagoons are being colonised naturally. This can take a number of years and so the vegetation, aquatic invertebrates and bird populations are being monitored to assess whether the lagoons can provide suitable habitat and sufficient food for birds. An area of wet grassland and ditches was also created to provide habitat variety.

The bird survey results in autumn/winter 2011 collated by the Leicestershire and Rutland Wildlife Trust were not available at the time of writing, but the 2010 surveys showed that the lagoons created in 2009 and 2010 were already attracting large populations of gadwall and shoveler. The carrying capacity of each lagoon had been calculated and the actual bird counts compared. In one of the lagoons built in 2009 both bird species were exceeding the calculated carrying capacity, while two built in 2010 were already achieving over 90% capacity for gadwall. It is hoped that in the final year of monitoring in 2015, all lagoons will have achieved their carrying capacity for the two species, and will be attracting many others.

In order for the new lagoons to attract these large numbers of birds, they need good invertebrate and plant populations to provide food. Both the 2011 macrophyte and macroinvertebrate surveys showed that some of the new lagoons had a higher diversity of aquatic invertebrates and plants than one of the existing lagoons. This is positive as it shows that the lagoons have colonised quickly, despite not being artificially planted. Their proximity to the existing reservoir and the frequent visits by birds is likely to have accelerated the process.

The monitoring results of the new lagoons at Rutland Water show that water companies can work with nature organisations to create and enhance aquatic habitats and help prevent local extinctions, while still allowing sufficient water to be available for human use. ES

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Images: Mott McDonald

The economics of biodiversity

Rupert Crilly says depending on the economic lens you use, biodiversity is loose change or big money

In 1145BC the Egyptian pharaoh Ramesses V succumbed to smallpox, one of the most devastating diseases in human history. For the next 3,000 years humanity was plagued by this disease, and with a mortality rate of thirty per cent, it killed around 400,000 Europeans every year during the mid 18th Century. It was not until 1796 that Edward Jenner demonstrated the effectiveness of cowpox to induce immunity against smallpox. And, in 1979 smallpox became the first disease to be eradicated by humanity and its ingenious use of genetic material. Cowpox, a nuisance virus to cows and milkmaids, had saved millions of lives.

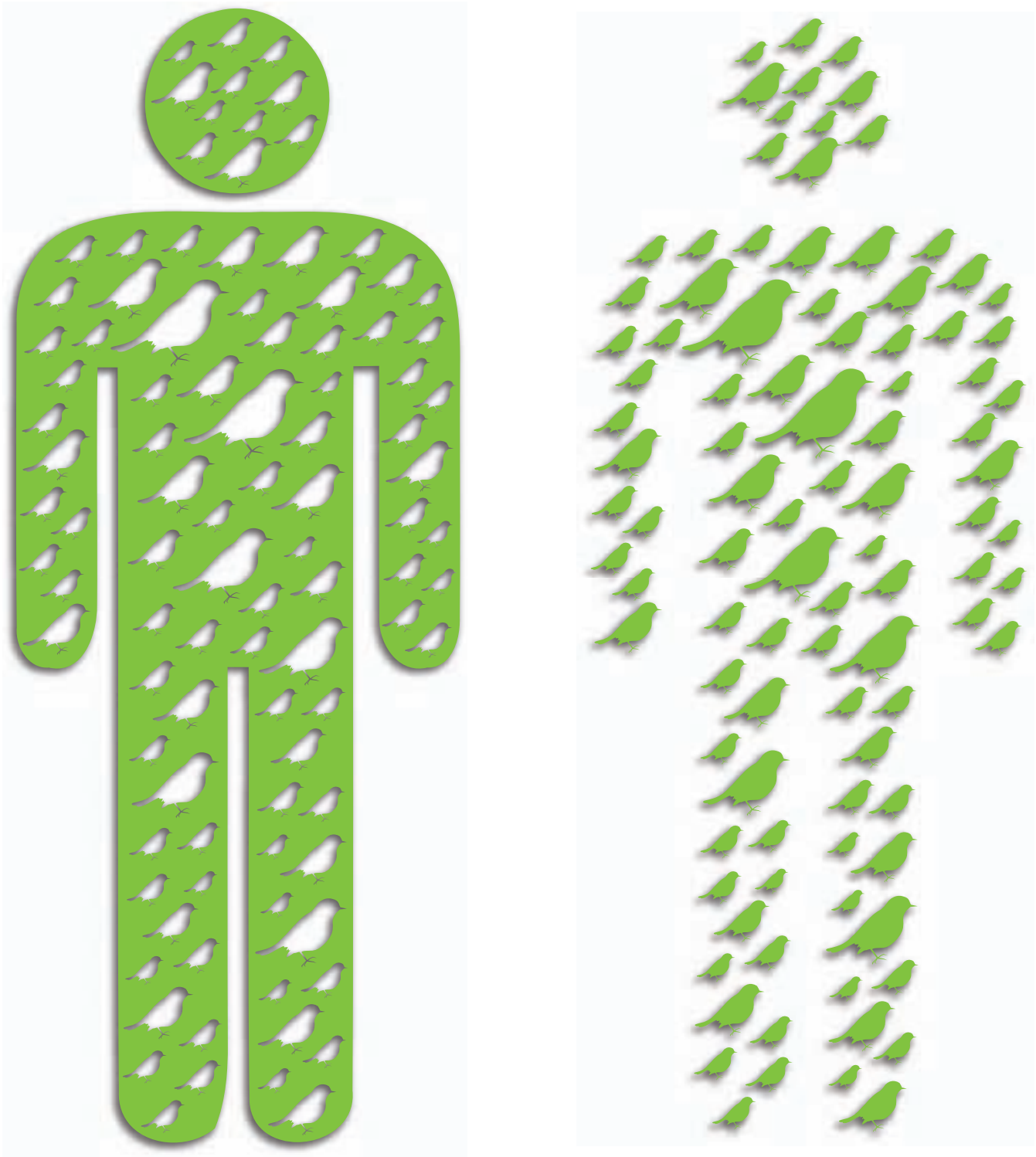
At its heart, valuing biodiversity is about valuing the fabric of life and solutions – particularly genetic– to our problems: curing medical diseases, providing diversity for all our food and its race against pests, ecosystem services such as regulating climate, and even inspiring military technology. But, with 8.7 million species on Earth (give or take 1.3 million), around 90% of which are undiscovered, can we save them all from our steamrolling economies[1]?

This question has been tackled from a variety of angles by economists. In each case, the costs of conserving a species, or its functional unit (such as an ecosystem) are weighed against the economic benefits, categorised into instrumental (use, non-use, option values), and intrinsic values. The foundations for the economics of extinction and the value of biodiversity were laid down by Clark in 1973[2]. In a seminal paper, he showed how an optimal economic strategy for a species could be its entire liquidation (or, its exploitation until it becomes too costly), taking the proceeds and investing in alternative resources[3]. Such a result is derived from cases where a species' growth rate is less than its owner's discount rate, and is even more costly in models with uncertainty about population dynamics[4,5].

Over the decades, this work has expanded to generalise the problem and its economic treatment[6]. Instead of a single species with well-defined benefits, the challenge is valuing the millions of species whose value may be completely unknown. One of the earlier treatments was the 'Noah's ark problem', which aimed to conserve the maximum biological diversity with a limited conservation budget[7,8]. Unfortunately, this still requires explicit social goals in the context of enormous uncertainty. For example, what kind of diversity should we preserve and for what purpose?

Another strand of the literature, particularly the contribution by Simpson, Sedjo and Reid[9], has a very specific approach to the problem whose solution is being sought by private companies. The cost of finding the right genetic material from a sample of appropriate species is balanced against the benefits such a discovery could make. This raises a number of issues, most critically the value of substitutability between species. To reduce the search costs for finding a genetic solution, it makes sense for a company to exclude (and therefore pay nothing to conserve) very similar species, and invest in only saving one. Yet, this approach also suffers problems. The difference between private value and social value can be complementary, on a different scale, or entirely opposite. Also, the number and type of problem requiring a solution could be predictable and sequential, or could be completely unknown. Nonetheless, the values they find for the industrial sector for some of the most biodiverse areas on Earth range from $2.59 per hectare in the Amazon to $20.63 per hectare in Western Ecuador, pitiful sums that inspire little faith in the courting of private investors to save biodiversity. Others have updated this literature to include more social value (e.g. consumer surplus) and include the importance of genetic resources for the evolutionary race (both economic and biological)[10].

The economic value of biodiversity depends on the discount rate we use and our beliefs about how risky and uncertain our future is. If the future holds a more unpredictable route, substitutable species suddenly become more valuable as an insurance policy[11]. Do we believe our future problems are similar to today's? Are



How many sparrows are worth a man?

we consistent in our social objectives? How do we value the risk of our own extinction?

The answer to these questions are not determined by economists, but by society and its political leaders. For example, Clark updated his famous result to show how the intrinsic (or existence) value of a species – how much we care about it even if we do not need or use it – could trump other considerations, and convert a species' otherwise dismal fate into a hopeful future[12]. This intrinsic value concerns the welfare of non-human species, though how this compares to the intrinsic value of people themselves is unknown. As Daly put it, "how many sparrows are worth a man?"[13] The obvious example is the panda, which is mostly useless to our economies, has fairly high conservation costs, but can contribute significantly to our (and their) wellbeing just by knowing it continues to exist (though, we should note, probably at the expense of other species). True, we

have data on prospecting success rates in the research and development industry, the rate of disease emergence in agriculture, and the rate of industrial technical change; but these all assume that our current problems, alleviated by an utterly unsustainable rate of resource use, are a good indicator of the kinds of problems we will face in the future when, as our economies are currently taking us, we will have far fewer resources and live in a more unstable world. Even if we believe a more precautionary approach is needed if we are to explicitly value our future generations, how precautionary should we be? Given the high stakes, some have begun storing genetic material (such as seed banks) for future problems. While a worthy safeguard in our alarming Anthropocene extinction, is it enough? Do we not need their preservation *in situ*, as part of well-functioning ecosystems?

The real value of biodiversity is evidently enormous, and extends well beyond the economists' human-centric focus; yet, the value we as a society are attributing to its conservation is pitifully small. This much The Economics of Ecosystems and Biodiversity (TEEB), as well as the UK's National Ecosystem Assessment, have shown us. But, the international community has taken far too long to begin tackling biodiversity loss. The Millennium Ecosystem Assessment in 2005 documented the state of the Earth's ecosystems and provided guidance for decision makers. Its findings were bad news: of 24 ecosystem services, only four had improved in the last 50 years, five were stable but threatened, while 15 were in serious decline[14]. Other initiatives have also helped bring attention to this fundamental issue, such as the Biodiversity Indicators Partnership. Market mechanisms such as biodiversity offsetting – which too suffer from the kinds of problem described above, as well as a lack of evidence on their effectiveness in tackling biodiversity loss – are a solution that pleases many but offers very little guarantee of stemming the tide, let alone in the time available.

In the thralls of a catastrophically high rate of biodiversity loss, running at around 1,000 times the background extinction rate, the United Nations declared 2010 the International Year of Biodiversity to highlight the problem. The decade 2011-2020 has become the United Nations Decade of Biodiversity, part of the Convention on Biological Diversity, with continued international negotiations. The worry, however, is that the intangibility of the problem and what it might mean for all stakeholders is something that might tempt an agreement without real action to back it up. In this author's opinion, the core issue is this: does society believe that our declining reserve of biodiversity is enough to solve the problems of the future? If we get this wrong, are we willing to pay the price of another smallpox? The answers to this have the potential to alter the entire structure of economies. Policy makers need to live up to this task. ES

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Ecosystem level extinction: Yasuni Biosphere Reserve

Gayle Burgess investigates the challenges and successes of Yasuni Biosphere Reserve in Equador in preventing extinction at the ecosystem level.

Since approximately the middle of the last century the pace of human 'progress' has been such that typically several species are simultaneously extirpated from the ecosystems humans seek to 'settle'. Rather than localised and even national level extinctions of individual species, humankind is now causing the rapid extinction of multiple species from ecosystems that, in their pristine state, demonstrate a high degree of complexity and finely balanced trophic layers. Occasionally, such places also provide homes for species with subtle specialisms that could yield some yet undiscovered benefit to science. Conservationists are consequently increasingly concerned that ecosystems are suffering 'defauning' in some areas at faster rates than 'deforesting'[1], and causing what has become evocatively known as 'Empty Forest Syndrome'[2].

ECOSYSTEM EXPLOITATION

A key driver of this distressing trend is the overexploitation of forest animals for food. In central Africa alone, it is estimated that the equivalent of four million cattle are hunted for wild meat annually. The Convention on Biological Diversity (CBD) calculates that if this need was to be met by local livestock instead almost 80% of the Democratic Republic of the Congo (DRC) would be set aside for pasture[3]. Recent research[4] has clarified that in the Congo Basin alone, 4.5 million tons of bushmeat are harvested annually; in the Brazilian Amazon, where six per cent of all species are listed on the International Union for Conservation of Nature (IUCN) Red List as threatened with extinction, the equivalent figure is around 23.5 million animals[5]. In the Central African Republic the proportion of wildlife being harvested beyond their ability to repopulate an area, has been estimated at 100%. In Sulawesi, the equivalent figure is 70%; in Bolivia 50% and Kenya, 43%[6]. Wild meat harvesting on this scale is clearly unsustainable.

Of course people need to eat, but in the last 40 years hunting wild animals for meat has escalated considerably. Once at a scale driven largely by local subsistence needs, bushmeat harvesting is now often observed as driven by the informal cash economy in regional domestic markets[7]. In some areas, it has become a full-scale commercial operation driven by national and even international consumer demand; diners in Asia and some areas of Europe are requesting ever more exotic dishes, and as a direct result, rare species are appearing on restaurant menus. The Born Free Foundation estimates that nearly 7,500 tonnes of illegal meat products enters Britain every year[8].

SPECIES PROGRESSION

When hunting at such levels proceeds unabated, the types of species caught alters over time thereby offering a proxy for the progression of ecosystem level extinctions. A study in Equatorial New Guinea between 1991 and 1996 indicated that at the start of the survey period around 2,000 kilograms of carcasses in the Malabo market each weighed over five kilograms (for example, antelopes and primates). By 1996 however, those in this weight category represented only slightly more than 750kgs total. Conversely, in 1991, just over 6,500 kilograms of carcasses each weighed less than five kilograms (such as rodents) but by the end of the survey period, this figure had almost doubled to approximately 11,500 kilograms. In addition to demonstrating a greater than 40% increase in the total volume of bushmeat harvested over five years, this shows a modal shift away from larger animals

Subsistence-level hunting of bushmeat is part of the traditional way of life of the Huaorani people

Photo credit: © UICN/TRAFFIC, Nicolás Kingman, 2011. Ecuador

AT A GLANCE: UN-REDD

The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries was launched in September 2008. The programme aids developing countries to prepare to implement national strategies for the valuation and protection of forests for the ability to store carbon. The goal is to move beyond deforestation and forest degradation to the sustainable management of forests and enhancement of forest carbon stocks.

to smaller ones: likely as a consequence of the former being 'hunted out'[9].

This gives several causes of significant concern; initially because of the impact on an array of critically endangered species, but also because local communities experience the immediate impacts of spiralling food insecurity and threatened livelihoods. Those people fortunate enough to get meat from the farm, not the forest, have the luxury of fearing the longer term impacts around climate change.

About 75% of tropical tree types are reliant on animals for seed dispersal, and their overexploitation is in some areas now at such a scale as to threaten the survival of the forest itself. This might sound alarmist, but CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), the CBD and CIFOR (Centre for International Forestry Research) have recognised the issue[10] and are collaborating through the CBD Bushmeat Liaison Group to tackle it. The body has indicated that helping to solve the 'bushmeat crisis' will not only save species, but also ecosystems and the local livelihoods dependent upon them. This is in addition to the cultural identity of indigenous communities that live in both primary and secondary tropical forests around the world, and the prospects of those banking (literally, though UN-REDD) on the role such landscapes play as carbon sinks[11].

SEEKING SOLUTIONS

Within this context, experts from more than 40 governments and UN agencies, intergovernmental organisations, and indigenous and local community organisations met in Nairobi in June 2011. A number of recommendations arose from delegates' deliberations, including some that previously seemed unpalatable, for example, instigating community wildlife management approaches, such as game ranching and hunting tourism. There was broad consensus that a paramount concern was the need to promote alternative local livelihoods and enable people to establish more sustainable ways to find meat to eat. Examples of such approaches are still rare enough themselves, but where they do occur, they can offer significant scope for hope.

The *Livelihood alternatives for the unsustainable use of bushmeat* report, prepared as part of the CBD Technical series by wildlife trade monitoring network TRAFFIC, identified a suite of ways in which today's wild meat harvesters could establish alternative ways to find food tomorrow. These ranged from keeping bees and breeding mini-livestock/indigenous species (for example, cane rats) through to more ambitious schemes around payment for environmental services and Certification.

YASUNI BIOSPHERE RESERVE

An initiative undertaken in the Yasuni Biosphere Reserve (YBR), Ecuador, combined a selection of these to great effect[i]. The national park at the core of the Reserve is widely celebrated as one of the most biodiverse places on Earth, and covers an area of approximately 982,000 ha. Within this is the Napo Tropical Moist Forest, one hectare of which typically contains over 650 tree species; more than the total number found in the United States and Canada combined.

The rare species richness was experiencing significant threat from unsustainable bushmeat harvesting. This arose from a combination of meeting the minimal subsistence needs of the indigenous Huaorani community, and additional harvesting by the same for commercial opportunities outside the area (associated with urbanisation across the broader Amazon basin). During a Wildlife Conservation Society survey in 2007, it was estimated that approximately ten tonnes of wild YBR animals were harvested annually. Overexploited species included the Guanta (*Cuniculus paca*), the Sahíno or Collared Peccary (*Pecari tajacu*) and the Huangana or White-lipped Peccary (*Tayassu pecari*). Others impacted included a sub-species of endangered Tapir (*Tapirus terrestris*), endangered river dolphin (*Inia*

Women are now trialling new recipes using alternative, more sustainable sources of meat

Photo credit: © UICN/TRAFFIC, Nicolás Kingman, 2011. Ecuador

g. geoffrensis), and many species of vulnerable or near threatened Amazonian fish.

In addition to damaging the integrity of the previously pristine natural systems within the Reserve, excessive hunting was also causing unpredictable consequences across social, economic and cultural landscapes. Indigenous hunters who caught wild animals would frequently receive only one fifth of the price paid for them in restaurants, and in addition to encountering difficulties as animals became more scarce, income levels would fluctuate wildly, leaving little security for those simply attempting to feed their families.

AMWAE (the Association of Wourani Women in the Amazon, Ecuador), supported by IUCN/TRAFFIC and Fundación Natura, approached women from the Huaorani community to identify a collaborative and appropriate solution. The *Diminishing Illegal Wildlife Trade in Yasuní* initiative was consequently established to provide alternative income sources for hunters. This was principally through the diversification of agricultural products, including the fair trade commercialisation of fine aroma cocoa. The high value cash crop was endemic to the area, and grown alongside citrus and avocado trees and traditional foods such as cassava and plantain in order to preserve a reasonably mixed landscape and protect biodiversity. This was combined with attempts to define and manage a more sustainable harvest of meat from wild animals, to enrich local diets and retain food sovereignty. A training and empowerment programme was run alongside this, enabling women to drive forward the decisions influencing daily life in their own communities, by negotiating better land access and tenure rights and playing an active role in regional governance forums and market economies. The project initially worked with 70 families whose hunting ranges spanned 200,000 ha within the YBR, but due to high profile success, has now been scaled up across the broader Amazon Region.

This brief analysis helps to illustrate how the contemporary experience of extinction is often now at the ecosystem, rather than simply species level. The causes of such a crisis can be comparably complex and those identifying solutions should not underestimate the extent to which the effort and collaborations behind identifying the response, must be 'in kind'. The scope and scale of preservation efforts need to encompass all aspects of society and ensure that the communities directly affected are able to co-design solutions with conservation practitioners, before adequate progress can be made towards ensuring sustainable protection of species, biodiversity and spaces. ES

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Further information is available in the following publication: *Gender, economic alternatives, and food sovereignty: Political strategies to bring about positive change to reduce commercial hunting in Yasuní.* Quito, Ecuador.

Driven to Extinction: The impact of climate change on biodiversity by Richard Pearson

Stephen Sutton reviews this recent publication investigating the interplay between climate change and extinction.

Bridging the gap between the science of climate change and civil society is one of the major challenges of the 21st century. If humanity gets it wrong in dealing with the problem the consequences by the end of the century could be far reaching, to put it mildly. Those trying to bridge this gap badly need feeds from steady minds to give policy makers and society at large a fair picture of what is known and what may happen. Richard Pearson, a researcher in the climate change and biodiversity field, has written a highly competent review for the non-academic reader. It is balanced, lucid and avoids force feeding.

He explains what is known about climate change, its potential effects on biodiversity, and the required policy shifts to manage substantial ecosystem changes which could severely test their carrying capacity for humans and cause a huge loss of biodiversity (in the worst case scenario well over 50% by year 2100).

The author is not well served by the title. 'Driven to Extinction' implies something definite which has already occurred, which is actually the exact opposite of what the author is trying hard to tell us. This not a polemic but an even-sided account of the current understanding about the probable impacts of climate change in the future.

Pearson tells us that we are facing a set of factors such as habitat fragmentation and overharvesting which may interact with climate change in extremely complicated ways. Current predictions are based on computer modelling, which is incapable of doing more than providing a wide range of probabilities under different scenarios. To an ecologist this is commonly understood – ecosystems are too complicated to make definite prediction of outcomes – but for the general public and their mouthpieces, the commercial and social media, probability is like a bar of soap in the bath, slippery and hard to handle.

The first chapter sets the scene. It begins by pointing out that biodiversity is not just something for scientists to study or for the rest to enjoy via television, it is an essential component of the ecosystems which support our daily lives. He goes on to state that climate change is a reality and has already impacted biodiversity. The evidence for both these statements comes from a wealth of research, nearly all of which points in the same direction and is increasingly difficult to dispute.

Although climate change is a reality, many people wonder if this episode is any different from previous climate change events in geological time. The author states clearly that this one is happening in decades, far faster than any previous case, and too fast for many species to adapt. The first chapter ends with an introduction to the idea of 'fingerprints' of climate change, unique traits providing compelling evidence that climate change has already impacted biodiversity over recent decades, for example upslope and poleward distribution shifts of species and advancing spring

PEARSON'S THREE FACTORS OF CLIMATE CHANGE

Pearson lists three factors of climate change and biodiversity interaction which make the problem serious:

- It is a truly global phenomenon;
- We are already committed to it through the 21st century; and
- There is a 'stealth threat'. It is in the nature of climate change to be gradual, and impacts on ecosystems are likely to be subtle in most cases, at first anyway. Often, therefore, there will be no massive jolt to public awareness of the kind generated by the Japanese tsunami in 2010, and thus less political drive to tackle the problem. However, ecosystems cannot be stressed forever, and some have already collapsed and been replaced by others when they reach a 'tipping point'.

phenology (e.g. birds migrating and breeding earlier).

Chapters two to four present well done and up-to-date in-depth reviews on large groups of plants and animals (among others: trees, plankton, birds, and frogs), spread over the whole globe from Madagascar to the North Sea and Costa Rica to China. In chapter five the stage is widened to examine the incidence of coral bleaching globally, in relation to El Nino/La Nina events and the thorny question of whether there is a sea level temperature rise involved as well. This is still debatable but it seems clear that El Nino events are becoming more frequent, suggesting a significant anthropogenic contribution. This leads on to a summary of the role of meta-analyses in trying to identify the problem of causation.

Pearson suggests that such analyses give 'strength in numbers' if many studies point to the same conclusion, and few would argue the point. Frequently the press takes up individual studies which do not support the consensus of climate change and anthropogenic causation because they make better news stories. That is just human nature, but meta-analyses demonstrate that the consensus is built on firm foundations.

The second half of the book looks towards the future. Chapter six details predictions of global vegetation models and bioclimate envelopes giving probabilities of how much biodiversity will survive under different climate change regimes. There is a very wide spread in the results, but the likelihood is a high risk of extinction for a significant proportion of plants and animals, particular those of low dispersal ability. Pearson is meticulous in pointing out the assumptions and weaknesses of these approaches, as well as their strengths. He ends the chapter with a detailed review of the work of Chris Thomas and his collaborators.

"Trying to determine when a species has actually gone extinct is notoriously difficult unless it is large and extremely limited in its range"

They assessed the extinction risk for over 1,000 species of plants and animals endemic (not occurring elsewhere) in regions chosen from around the globe. For temperature change at the lower end of what is forecast, they predict that 23% of species will be 'committed to extinction' by 2050.

The term 'committed to extinction' has problems, as it invites the vision of lemmings leaping over Nordic cliffs determined to die. With climate change, no such commitment is necessary. Perhaps the more neutral term 'latent extinction' is more accurate, as it expresses how these populations have reached the point where reproduction and immigration are too low to sustain numbers. They are therefore already extinct, but in a hidden way. A population of long-lived animals or plants can be latently extinct for decades, a 'stealth' problem with the species still existing and seeming not to be in terminal decline. Trying to determine when a species has actually gone extinct is notoriously difficult unless it is large and extremely limited in its range. Censusing in depth to establish population viability is a very expensive business and usually limited to iconic or suspected keystone species.

Another problem with extinction forecasts is that before a species finally becomes extinct it has almost always been reduced in range to a habitat sweetspot where it is most at home. That means over the majority of its range it has already become locally extinct and is no longer contributing to ecosystem service functions like water retention, food supply or tourism dollars.

We are morbidly fascinated by extinction due to its finality, but in practice we should be more concerned by the current large-scale local extinctions associated (for example) with the conversion of rainforests to other land uses. In Borneo, the timber value of undisturbed

"We are morbidly fascinated by extinction due to its finality, but in practice we should be more concerned by the current large-scale local extinctions"

lowland primary dipterocarp forest (hardwood, tropical trees) is so great that only around ten per cent is left. Only five per cent of that is in reserves, with the rest likely to go soon. What is left is secondary, regenerating forest which is actually comparatively rich in biodiversity but missing the canopy and deep shade specialists confined to primary stands.

Secondary forest tends to be cut on a 20 or 30 year cycle, leaving tall scrub with grassy patches. This then becomes viable for oil palm plantations who can fairly claim that this kind of ecosystem has lost most of its ecosystem service value and therefore can arguably be turned into plantations (with biodiversity almost off the bottom of the scale). The impact of climate change on Borneo's forests will most likely be through drought. During El Nino induced dry weather in 1982/83 and 1997/98 huge areas of Borneo's forests burned, mostly ending up under oil palm. Even without fire, long droughts cause great tree mortality and shift the species composition of the forests.

But to return to the book. Chapter seven looks at present climate change in relation to evolutionary capacity and concludes that although rapid changes are known, for most species the rate of climate change exceeds their rate of adaptation. Chapter eight examines the complexity of ecosystem function and the difficulty this creates for prediction of climate change impact and how some outcomes are counter-intuitive.

Chapter nine is very valuable and very unusual, moving beyond analysis of research to the role and responsibilities of the scientist in society. Pearson highlights the danger of overstating the problem of climate change, and thereby alienating society when predictions do not come true. It promotes the idea that the scientist should be the 'honest broker', bridging the gap between the science and society. I think this is notably well written and essential reading for any scientist or administrator involved in environmental research.

Chapter ten gives prescriptions for 21st century conservation to limit biodiversity loss, soundly based on the preceding chapters. One can cavil at one or two mistakes, the irritating use of degrees Fahrenheit instead of Celsius and the need for more emphasis on the importance of local extinction, but this is a very good book and a real service to the global environmental community. ES

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IES: New members and re-grades

Name	Occupation	Grade
Mark Amos	Environmental Scientist	A
Stephen Barnes	Environmental Field Engineer	M
Abigal Bennett	Student	Af
Dionne Biddie	Environmental Consultant	M
Richard Biney	Senior Geo-Environmental Engineer	A
Patricia Bowe	Consultant (Air Quality)	M
Martin Brown	Stake Emissions Monitoring Team Leader	M
Michael Buckley	Principal Consultant	M
Thomas Cahill	Environmental Engineer	M
Peter Cairns	Water & Sewage Operations Manager	M
Alasdair Cameron	HSEQ Coordinator	M
Lucia Cavalcanti-Vervecken	Graduate	A
Chun Pong Chan	Environmental Officer	A
Huanjie Chen	Senior Environmental Consultant	M
Gemma Clark	Technical Consultant	M
Lisa Clarke	Environmental Consultant	A
Andrew Davies	Emergency Response Coordinator	A
Chandra Kripa Dwarakanath	Senior Consultant	M
Lisa Dymock	Scientist	M
Barry Edwards	Consultant	A
Guy Elliot	Regulatory Officer	M
Robert Epsom	Environmental Consultant	A
Chukuemeka Emmanuel Ezeaku	Graduate	A
Chloe Fellows	Assistant Air Quality Consultant	M
Stacie-Ann Fongo	Geo-environmental Engineer	M
Madara Gaile	Student	Af
Lindsey Geddes	Environmental Scientist	M
Hannah Gordon	Graduate	Af
Paul Grimes	Health, Safety & Environmental Manager	M
Kung Hau	Assistant Environmental Officer	A
Julia Heaton	Green Academy Programme Assistant	A
Lee Heffernan	Environmental Health Technician	M
Kevin Herman	Senior Consultant	M
Emma Hillier	Student	Af
Suzanne Hodgson	Senior Consultant	M
Matthew Hogg	Environmental Consultant	A
Michael Holmes	Student	Af
Danielle Humphrey	Graduate	A

IES: New members and re-grades

Name	Occupation	Grade
Saferio Inganga	Chief Environmental Research Officer	A
Ruth Jones	Environmental Scientist	M
Richard Jones	Graduate	A
Anna-Kaisa Karki	Engineer	M
Andrew Kent	Senior Consultant	M
Richard Kent	Project EIA Consultant	A
Henry Lee	Student	Af
Michelle Lewis	Environmental Consultant	M
Joseph Martin	Environmental Scientist	M
Patricia Matthews	Lab Assistant	Af
Rebecca McClenaghan	Senior Environmentalist	M
Rachel McHale	Senior Air Quality Consultant	M
Eimear McKenna	Graduate	A
Corinna McShane	Stakeholder Communications Manager	A
Richard Mensah	International Project Assistant	M
Matthew Mitchell	Senior Environmental Consultant	M
Charlotte Monkhouse	Graduate Environmental Scientist	A
Phillip Morris	Senior Scheme Manager	M
Ogbonnaya Richard Nwali-Okereke	Graduate	A
Mella O'Driscoll	Consultant	M
Neela Pandey	Graduate	A
Davide Pascarella	Technical Officer	M
Rachel Powis	Graduate	A
Oliver Puddle	Environmental Scientist	M
Ian Ramsbottom	Environmental Scientist	M
Jeanette Reith	Environmental Health Technician	M
Matthew Ryder	Environmental Consultant	M
Lyndon Sackey	Landfill Supervisor	A
Thomas Sale	Graduate	A
Keisha Smith	Senior Engineer	M
Angela Tonge	EMEA Environmental Compliance Specialist	M
Helen Walker	Air Quality Consultant	M
Benjamin Warren	Senior Consultant	M
Antony Wiatr	Environmental Consultant	M
Elisha Williams	Senior Assistant Air Quality Consultant	M

KEY	F = Fellow	M = Member	A = Associate	Af = Affiliate