PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

The Loss of Banks's Legacy [and Discussion]

C. J. Humphries, C. T. Fisher and N. J. Collar

Phil. Trans. R. Soc. Lond. B 1994 **344**, 3-9
doi: 10.1098/rstb.1994.0044

The loss of Banks's legacy

C. J. HUMPHRIES[1] AND C. T. FISHER[2]

[1]*Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.*
[2]*National Museums and Galleries on Merseyside, Liverpool Museum, William Brown Street, Liverpool L3 8EN, U.K.*

SUMMARY

Sir Joseph Banks had a profound love for nature and would have been horrified to witness the destruction and modification of the world's natural habitats since his time, particularly as his own exploration efforts and agricultural interests contributed directly to the colonization of Australia and many Pacific islands. Unprecedented population growth and huge changes in human mobility in the last 250 years have created a wave of extinctions of many plants and animals throughout the world. In an effort to assess Banks's legacy and calculate rates of extinction on a historical timescale, we examine changes since 1740 to the birds, mammals and vascular plants of three areas: Australia, the Hawaiian Islands, and the British Isles.

1. INTRODUCTION: SIR JOSEPH BANKS (1743–1820)

Born into a wealthy Lincolnshire landowning family with roots in Yorkshire, and with a passion for natural history from his early Eton schooldays, Sir Joseph Banks was one of the greatest figures in Georgian England. Best known to us perhaps as the youthful, wealthy dilettante who played a distinguished role as a naturalist on the Endeavour voyage with Captain Cook, he was elected President of the Royal Society in 1778 at the age of 35. He remained in that office for 42 years until his death in 1820, its longest-serving occupant. Although frequently described as a gout-ridden autocrat by disgruntled contemporaries and later biographers, Banks was a man of great stature, who for nearly half a century dominated the centre of scientific and political progress in Great Britain and Western Europe, and presided over some of the most profound changes during the age of reason.

Throughout his career, Sir Joseph Banks received many honorary degrees and civic awards, including a Baronetcy and the Order of the Bath. However, neither wealth nor respectability dulled his natural energy and zest for new ideas. His period as President of the Royal Society and Privy Councillor has been likened to that of the career of a freelance Cabinet Minister. From his London residence at 32 Soho Square he became involved in many schemes. These ranged from the development of the Royal Botanic Gardens at Kew and their living plant collections to the foundation of the Ordnance Survey, and the origins and progress of the convict settlements at Port Jackson in Australia.

In his early career, between 1769 and 1771, Banks travelled on the *Endeavour* voyage with Lieutenant James Cook. Apart from bringing back some 4000 species of plants and animals (Diment *et al.* 1984), Banks and his colleagues had seen several countries new to Europeans, and it was in Botany Bay that he first realized the economical and colonial potential of Australia. On his return he persuaded King George III that much could be gained from exploiting the huge potential of Australia, and by 1788 the first English settlement had been founded in Port Jackson, an event which became one of the great turning points of world history.

In the second phase of his career, Banks pioneered many new ventures which had notable impact throughout the expanding British Empire, but especially in Australia. In the summer of 1801, one small event occurred that heralded capitalist growth and world domination by Great Britain in the 19th Century wool trade. On 9 July, Joseph Banks delivered eight wool fleeces to the Bermondsey wool stapler, Henry Lacocke, a consignment from Australia which included just a few pounds of fine wool sheared from one old ewe and her one-year-old offspring ram. The rest is history: sheep trading has been prominent in Australia and New Zealand ever since (Carter 1988).

The turn of the 19th Century might have seemed a depressing prospect to a man nearly 60 years of age, when the average lifespan at that time was little more than 35 years. However, Banks maintained his scientific curiosity and the course of his capitalist ventures by using his influence both in the Royal Court and over the careers of others. He was at his most influential over the preparations for the Flinders voyage (1801–1805) (see Edwards 1981), especially his suggestions of sending Peter Good as gardener, Robert Brown as botanist and Ferdinand Bauer as artist. Peter Good unfortunately died at sea in 1803, but when Brown and Bauer eventually returned in 1805, they brought back 38 cases of specimens and

Phil. Trans. R. Soc. Lond. B (1994) **344**, 3–9
Printed in Great Britain

drawings, the material basis of the first flora of Australia (Brown 1810). Throughout this period, and for years to come, Banks's influence assured that a steady stream of seeds and live plants arrived at Kew. He added dried specimens to his own collections through a string of collectors in the field, including such acolytes in Australia as George Caley, John Lewin, Robert Brown, Allen Cunningham and George Suttor.

It is worth noting that Banks had profound interests in the English countryside. In addition to his general fondness for natural history, he had deeply philosphical and practical interests in farming and horticulture. Topics in which he was well versed included sheep breeding, land management, plant pathology of rust diseases in cereal crops, acclimatization of plants for the English countryside, strawberry growing, forestry and agricultural chemistry. He ran his own estates and was heavily involved with land reform.

In what follows, we consider extinctions in recent history by examining Joseph Banks's legacy in Australia and Hawaii, make some brief remarks about the United Kingdom, and compare these to recent global estimates (Groombridge 1992; Smith *et al.* 1993*a*,*b*).

2. EXTINCTIONS IN RECENT HISTORY

(*a*) *Australia*

Archaeological remains have shown that Aborigines have had at least 40 000 years of continual occupation of Australia and had already made considerable impact on the native vegetation (Saunders *et al.* 1988). They increased the frequency of fires in grasslands, they introduced new animals such as the dingo, and they contributed to the decline and extinction of indigenous animals through hunting. Great as these changes might seem, they occurred over thousands of years. Aborigines lacked the technology necessary to create drastic change, and there appears to be little evidence that they altered the vegetation very much. There seem to be few sites which have shown continuous occupation and profound alteration by Aborigines, although some rainforest gymnosperms, e.g. *Dacridium*, had disappeared before European arrival (Clark 1988). It can be argued that the greatest changes over the last 40 000 years have come about through global changes in the climate, Australia becoming colder and drier about 20 000 to 16 000 years ago, and then warming up to the present interglacial.

The overall impact of the first European settlers, together with subsequent waves of immigration, has been enormous. After the first 25 years of the settlement's existence, the ecology of the Port Jackson region was changed dramatically, affected initially through hunting on a grand scale, but mainly through imported mammals and northern seed stocks.

Very rapidly, other areas became ecologically challenged as Europeans moved further inland, with the most dramatic impacts on the environment coming in the latter half of the 19th Century and the first half of the 20th Century. Europeans imposed their northern ideas of civilization on to huge areas of the continent, with little thought as to the fragility and vulnerability of the Australian landscape. The extent of the changes that have taken place might not be as dramatic as those that have taken place over geological time, but the rates of change have been quite frightening. Furthermore, the changes have not been simply transformations of one land form to another, but severe reconstruction and degradation on an unprecedented scale (Morton 1988; Saunders *et al.* 1988).

Over the last 200 years, 70% of the floral and faunal communities which existed in 1788 have been modified, over 65% of the original tree cover removed, and up to 75% of the rainforest cleared for grazing and agriculture. As a result of wholesale exploitation, 55% of arid lands and 45% of non-arid areas require treatment to reverse land degradation, and 4.2 million ha are affected by salting after tree felling and land clearance (Hobbs & Hopkins 1988).

Of the 522 species of birds (1175 taxa including subspecies) (Mathews 1930; Peters 1931–1987; Condon 1975; Fisher 1992), it is the flightless or ground-living birds that have suffered most, the emu populations in particular (table 1). Although the continental emus survive in large numbers, at least two island forms of Dromaiidae have died out. The Kangaroo Island and Tasmanian emus are known to be extinct. Of parrots, the Paradise parrot has not been seen since 1927 (King 1981), although the night parrot (*Geopsiattaceus occidentalis*), thought for years to be extinct, has recently been rediscovered (W. E. Boles, personal communication). Two other birds are possibly extinct: the rufous bristlebird and the double-eyed fig parrot (Greenaway 1967; Frith 1979).

There are 20 species of mammals thought to be globally extinct out of a total of 263 described (Strahan 1983; Inskipp & Barzdo 1987; Fisher 1992) (table 1). Both marsupials and placental mammals have been badly affected. It is particularly noticeable how many of the forms collected by John Gilbert between 1838 and 1845 are now extinct. The rat-kangaroo named after him, a form of long-nosed potoroo, which occurs only in Western Australia, was made extinct by aborigines. A related species, the broad-faced potoroo, was already rare at the time of its discovery, and the last known capture was in 1875 (Strahan 1983; Inskipp & Barzdo 1987).

Many extinctions seem to have taken place due to a lethal cocktail of introduced cats and foxes, European agricultural practices and bush fires (Tyler 1978). Introduced European foxes have contributed to the demise of two species of hare-wallabies, and hunting by man for soft pelted animals has helped towards several extinctions of the bandicoot family (table 1). The Toolache wallaby was last seen in 1927, and several species of hopping mice, *Notomys*, became extinct in the latter half of the 19th Century (table 1). A most tragic extinction was caused by deliberate hunting of Thylacines. The Tasmanian wolf at one time lived on mainland Australia, but gradually died out as dingos began to spread. Their last remaining foothold was in Tasmania where they were hunted to

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Table 1. *Extinct birds and mammals of Australia*

common name	Latin name	last seen
birds		
Paradise parrot	*Psephotus pulcherrimus*	1927
Kangaroo Island emu	*Dromaius minor*	1827
Tasmanian emu	*Dromaius novaehollandiae diemenensis*	1865
rufous bristle bird	*Dasyornis broadbentii litoralis*	1916
double-eyed fig parrot	*Psittaculirostris diophthalma coxeni*	1976
animals		
thylacine	*Thylacinus cyanocephalus*	1933
pig-footed bandicoot	*Chaeropus ecaudatus*	1920
desert bandicoot	*Perameles eremiana*	1931
lesser bilby	*Macrotis leucura*	1931
central hare-wallaby	*Lagorchestes asomatus*	1931
eastern hare-wallaby	*Lagorchestes leporides*	1890
toolache wallaby	*Macropus greyi*	1927
crescent nailtail wallaby	*Onychogalea lunata*	1964
broad-faced potoroo	*Potorous platyops*	1875
white-footed tree rat	*Conilurus albipes*	1840s
lesser stick-nest rat	*Leporillus apicalis*	1933
short-tailed hopping mouse	*Notomys amplus*	1894
long-tailed hopping mouse	*Notomys longicaudatus*	1901
big-eared hopping mouse	*Notomys macrotis*	1843
Darling Downs hopping mouse	*Notomys mordax*	1840s
Alice Springs mouse	*Pseudomys fieldii*	1895

extinction by intolerant settlers because of their penchant for introduced sheep. The last known capture took place in 1930; it died in captivity in 1933 (Strahan 1983).

The richness of the Australian flora is rather hard to gauge accurately, but is probably in the region of 20 000 species. For the whole continent, 3330 species are considered to be completely extinct, rare or endangered. According to the latest censuses, 165 species of plants are now considered extinct (Groombridge 1992), 209 endangered, 784 vulnerable, 1367 rare, and another 872 poorly known (Briggs & Leigh 1988). Thus about 5% of the flora is extinct or under immense pressure. Areas that particularly need investigation include Western Australia, Cape York Peninsula and Northern Territory (Woinarski & Braithwaite 1990).

The European impact on the fauna and flora of Australia has been described by Hobbs & Hopkins (1988) as a change from 'frontier to fragments', and more precisely by Godron & Forman (1983) as 'removal, replacement and utilisation'. It seems that birds have fared better under the changing landscapes, with only one mainland species, the Paradise parrot, actually becoming extinct. Morton (1990) has argued that birds in the semi-arid and arid areas have the ability to move easily and thus survive in an ecological system in which grazing pressure reduces available refugia. In the mallees and coastal heathlands of the southeast and southwest, habitat fragmentation and unsuitable fire régimes have diminished the survival-through-dispersal strategy for some birds, particularly for some bristle birds, and ground-living parrots which fly poorly. As a result, these areas now contain more rare and endangered bird species than any other habitats in Australia (Woinarski & Braithwaite 1990).

The graveyards for mammals have been central and southwest Australia and mallee. Mammal populations have declined from habitat transformation through land clearing, unsuitable fire régimes, grazing, introduced predators, and occasional hunting (Woinarski & Braithwaite 1990). Plants have many threats (30 identified in the ANZAC review), and frequently more than one threat at a time: removal for agriculture, weed competition, horticulture, and plantation forestry, urban settlement, transport, fires, collecting, industrial development and extractive processes have caused most extinctions (Leigh & Briggs 1992).

(*b*) *Hawaii*

The purpose of Captain Cook's third voyage (1776–1780) was to find a North-West passage from the Pacific Ocean to the Atlantic Ocean. On 18 January 1778, Captain Cook and the crew of the *Resolution* got their first glimpse of the Hawaiian islands after a long voyage from Tahiti. At the time of their arrival, the human population of the Hawaiian islands was estimated at between 30 000 and 50 000, which had originated from seafaring immigrants from the Marquesas and Tahiti 1000–1500 years ago. The original immigrants could not have numbered more than a few hundred people, but the Polynesian success at populating the Hawaiian islands had far-reaching effects on the biota (Wagner *et al.* 1991).

The Polynesians introduced exotic plants, raised crops and burnt down the forests. At the time of the arrival of the *Resolution*, the native biota consisted of 1200–1300 species of flowering plants, and at least 220

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Table 2. *Extinct birds of Hawaii*

common name	Latin name	locality	last seen
Hawaiian rail	*Porzana sandwichensis*	Hawaii	1884
Laysan rail	*Porzana palmeri*	Kure, Midway Laysan	1944
amaui	*Myadestes oahensis*	Oahu	1820
	Acrocephalus familiaris	Laysan	1916
Oahu oo	*Moho apicalis*	Oahu	1837
Hawaii oo	*Moho nobilis*	Hawaii	1934?
kioea	*Chaetophila angustipluma*	Hawaii	1860
lesser koa-finch	*Rhodacanthis flaviceps*	Hawaii	1891
greater koa-finch	*Rhodacanthis palmeri*	Hawaii	1896
Kona grosbeak	*Chloridops kona*	Hawaii	1894
greater amakihi	*Hemignanthus sagittirostris*	Hawaii	1900?
akialoa	*Hemignanthus obscurus*	Kauai, Oahu, Lanai Hawaii	1960
kakawahie (Molokai creeper)	*Paroreomyza flammea*	Molokai	1963
ula-ai-hawane	*Ciridops anna*	Hawaii	1892
Hawaii mamo	*Drepanis pacifica*	Hawaii	1899
black mamo	*Drepanis funerea*	Molokai	1907

species of birds (see Pimm *et al.* (this symposium) for a reappraisal of the original, intact avifauna of these islands). About 90% of the plants were endemic. However, the leeward slopes were bare, except for pili grass which was encouraged to grow through burning, and used by the Hawaiians for thatching houses (Wagner *et al.* 1991). Originally there were no native terrestrial animals, but Polynesians imported dogs, pigs, rats and jungle fowl. Pigs damaged fragile habitats by rooting up the soil and allowing weeds into the resulting bare patches, effectively reducing native plants. Rats killed birds, particularly flightless and ground-nesting species. However, the biggest ecological disasters were caused by elimination for agriculture of much of the dryland and mixed mesic forests that covered the leeward sides of the islands. How these forests originally looked we shall never really know, but they were probably decimated well before the arrival of Cook and his crew (Sohmer & Gustafson 1987).

Pimm *et al.* (this symposium) review the massive extinctions of birds that have taken place on the Hawaiian islands. Their analyses will not be repeated here. We know, for example, from fossil discoveries that nearly 50 species of flightless birds, including seven species of flightless geese and a flightless ibis, once existed in the Hawaiian islands (Olson & James 1984). The list of passerine bird extinctions is particularly long. Of the 29 honeycreepers (Drepanidae) species known to have occurred at the time of Cook's arrival, nine are probably extinct and at least 13 are endangered (table 2; Pratt *et al.* 1987).

Since European contact, many more critical ecological disturbances have come about as a result of assaults on the wet forests of the mountains and windward slopes. The damage has generally been less dramatic than that of the dry forests on the islands but with potentially longer-lasting effects. The huge numbers of alien plants and animals introduced since initial European contact – many of which now have become serious pests – have had a profound effect on the native biota, especially within the wetter forests.

Changes to plant communities have been profound. When compared with alterations to the landscape caused by Polynesian settlers, the speed of changes to the vegetation accelerated greatly after the arrival of Europeans. Today, cattle pastures account for 50% of the land area, urban conurbations and plantations account for another 30%, leaving only 20% for remaining communities which are increasingly mixed with alien species. Of the forest, 80% has been destroyed by fire, and grazing and arable crop planting has profoundly affected native plants.

The recorded flora stands at 1094 native species. Since the *Resolution* arrived in 1778, 423 (38%) are considered to be extinct or threatened, 107 (10%) are believed to have become completely extinct, 139 (12%) are now endangered, 39 (4%) are vulnerable, and 138 (12%) are rare (Wagner *et al.* 1991). Other plants are bound to become extinct as even more exotic species arrive on the islands. Introduced plants often grow better than natives, particularly after natural habitats have been disturbed. The number of naturalized plants in Hawaii has steadily grown. The Polynesians had already introduced about 30 species of flowering plants, mostly for food, medicine and shelter (Abbott in Sohmer & Gustafson (1987)). By the 1890s approximately 150 species had been introduced, mostly by Europeans. Today literally thousands of plants have been introduced into the islands from all over the world, of which 800 species are known to have now become firmly established (Sohmer & Gustafson 1987; Wagner *et al.* 1991).

(*c*) *United Kingdom*

Sir Joseph Banks was a wealthy citizen of England, having added considerably to his original inheritance as farmer and landowner. He wielded great influence on agricultural practice, and one of his most ambitious projects, which eventually took three Acts of Parliament and half a century to implement, was the draining of the East, West and Wildmore Fens in Lincolnshire (Carter 1988). These fens were at that time perhaps the finest examples of wetlands in the U.K., and the social changes for people whose ances-

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

tors had been fen workers for centuries were considerable in this respect. The drainage caused waterfowl and fish to be lost from the fens for good (Carter 1988), but it is unlikely that we will ever know whether these destructive practices actually caused extinction of species.

The British Isles then, as now, cannot really be seen in an isolated context, but rather as a relatively impoverished corner of northwest Europe. Native species are mostly western ranges of palearctic taxa, with very few endemics apart from a few apomictic plants, several mammal subspecies, the Scottish crossbill, a few species of fish, and many invertebrates.

Since the Neolithic, some 50 000 years ago, the environment has been profoundly modified by man. Little in the way of natural vegetation or habitats now remain in Europe, except around lakes, mountains and marshes. The European megafauna has been greatly diminished by man since the end of the Pleistocene. Global extinctions of mammals include the woolly rhino, woolly mammoth, the Irish elk, and the crane, *Crus primigenia*, and the European lion is believed to have survived until Greek times. Several species became extinct in the Middle Ages, and the auroch, *Bos primigenius*, disappeared in 1627 (Harting 1880; Corbet & Harris 1991). The only global bird extinction since Banks's time (which occurred through overharvesting and persecution) is the great auk, *Alca impennis*, which was formerly distributed throughout Atlantic nesting sites including Britain and Ireland.

The distributions of plants in Britain and Ireland have been continuously recorded for more than 350 years (Fisher 1987), and the U.K. flora is considered to be one of the best known in the world. The total flora, including all natives, casuals, crop plants and hybrids, is about 2990, of which probably only 1500 are considered truly native (see Stace 1991). Since the time of Banks, only about 19 species are considered to have become extinct (Perring & Farrell 1983; Curtis & McGough 1988), but at least another 93 are now considered endangered or vulnerable (including many cornfield weeds), about 330 species are rare, and 201 exceedingly rare (Stace 1991). The principal cause of change in the U.K. and Ireland has been the mechanization of agriculture over the last 100 years or more, and industrialization of farming in the post-war period.

(*d*) *The global picture*

Smith *et al.* (1993*a*,*b*) provide a useful picture of current world extinction rates of plants and animals. Since 1600, 486 animal species have been recorded extinct, which represents 0.04% of the total, and 600 plants are presumed extinct, about 0.25% of the total. The results initially do not seem worrying against a geological background of extinction, but they clearly represent underestimates rather than overestimates, and point to relatively recent changes of extinction rate. Smith *et al.* also point out that, although many regions have been able to produce reasonable faunistic and floristic accounts, the data on extinction rates are still inaccessible and cannot be used for analysis.

The animal data (last recorded dates are generally unavailable for plants) appear to show that a sharp increase in the extinction rate took place between 1850 and 1950 (Smith *et al.* 1993*b*, their figure 1), coinciding with a relentless rise in European colonial expansion. This followed the age of exploration, which was effectively accelerating during Joseph Banks's lifetime. The impact of Europeans was not only making itself felt in the Pacific but around the whole world. The utilitarian attitudes of the industrial revolution were spread along the paths of the voyages of exploration, and the extinction rates determined by Smith *et al.* (1993*a*,*b*) probably reflect to a great extent the plundering of natural resources to fuel the growth of industrial capitalism: an attitude that still prevails in many countries, including this one, today. Our human population pressure is still dramatically transforming the landscapes, and we still have to consider the prospects.

3. CONCLUSIONS

Here we have provided a mere sketch of extinction rates in recent history, by examining three relatively well-documented areas of the globe which have been affected by relatively long-term occupation; we have also seen that a similar picture probably prevails throughout the world, and the problem is likely to be far greater in the tropics (see Groombridge 1992). The impact of humans on natural habitats goes back a long time, in many cases to before 1600 and even prehistoric times in Europe and the U.K. Elsewhere, such as in the Hawaiian islands and Australia, rates of extinction have accelerated alarmingly since the time of Sir Joseph Banks. Although assessments of extinction rates give us an impression of the size of the problem, they cannot tell us how to slow down these rates. The task for the future is to discover ways of reversing the process of degradation and to preserve the various remaining pieces of our natural heritage. Landscapes are fast becoming denuded and reduced in overall biodiversity, and former natural habitats are settling to new, less rich equilibria of exotic and native species.

Rather than focus on refining ways of measuring extinction rates, we believe we need to assess and measure biodiversity in recognizable areas or localities on a comparative basis, by using methods that are currently being developed by a number of agencies in Australia, America, Canada, South Africa and the U.K. (see Margules *et al.* 1988; Pressey *et al.* 1993; Forey *et al.* 1994). Ecological restoration of natural habitats will be a primary activity in the next century. Our analyses today should be used to identify networks of irreplaceable areas that should be maintained at all costs, and to identify other areas in terms of their comparative importance. The conservationists of the late 20th Century have begun to realize that much more will have to be done than we are doing already to stem the tide of accelerating species extinction and habitat modification. We have learned a lot from Banks's legacy. His collections at the Natural History Museum and Kew Gardens paved the way for

understanding the rich biotas of the Pacific, and his early scientific explorations and social experiments led to entire new nations being formed. However, today much of the modern world is at odds with nature. The Banksian legacy might have nourished our natural curiosity, but at the same time was part of the human movement that has modified and impoverished the environment in which we live.

We thank all of our many colleagues who actively took part in our extinction survey, Ronald Keay for unpublished materials regarding Joseph Banks, Mary Briggs for details of the British flora, Robert Prys-Jones for details on birds, and Bob Pressey for recent references on Australian flora and fauna.

REFERENCES

Briggs, J.D. & Leigh, J.D. 1988 *Rare or threatened Australian plants*. (Special publication No. 14.) Canberra: Australian National Parks and Wildlife Service.

Brown, R. 1810 *Prodromus Florae Novae Hollandiae et Insulae van Diemen*. London.

Carter, H. 1988 *Sir Joseph Banks*. London: British Museum (Natural History).

Clark, R.L. 1988 Ecological history for environmental management. In *Australian ecosystems*; *200 years of utilisation, degradation and reconstruction* (ed. D. A. Saunders, A. J. M. Hopkins & R. A. How), pp. 1–21. Chipping Norton, Australia: Surrey Beatty.

Condon, H.T. 1975 *Checklist of the birds of Australia. I. Non-passerines*. Carlton, Victoria: Royal Australasian Ornithologists' Union.

Corbet, G.B. & Harris, S. 1991 *The handbook of British mammals*, 3rd edn. Oxford: Mammal Society & Blackwell Scientific Publications.

Curtis, T.G.F. & McGough, H.N. 1988 *The Irish red data book. 1. Vascular plants*. Dublin: Wildlife Service Ireland & The Stationery Office.

Diment, J.A., Humphries, C.J., Newington, L. & Shaughnessy, E. 1984 Catalogue of the natural history drawings commissioned by Joseph Banks on the Endeavour voyage 1768–1771 held in the British Museum (Natural History). *Bull. Br. Mus. nat. Hist.* **11**, 1–183.

Edwards, P.I. 1981 The journal of Peter Good. *Bull. Br. Mus. nat. Hist.* **9**, 1–213.

Fisher, C.T. 1992 *The importance of early Victorian natural historians in the discovery and interpretation of the Australasian fauna, with special reference to John Gilbert*. Unpublished Ph.D. thesis and database, C.N.A.A./Liverpool John Moore's University & National Museums and Galleries of Mersyside.

Fisher, J. 1987 *Wild flowers in danger*. London: Victor Gollancz.

Forey, P.L., Humphries, C.J. & Vane-Wright, R.I. (eds) 1994 *Systematics and conservation evaluation*. Oxford University Press.

Frith, H.J. 1979 *Wildlife conservation*. Australian National Science Library & Angus & Robertson.

Godron, M. & Forman, R.T.T. 1983 Landscape modification and changing ecological characteristics. In *Disturbance and ecosystems, components of response* (ed. H. A. Mooney & M. Godron), pp. 12–28. New York: Springer.

Greenaway, J.C. 1967 *Extinct and vanishing birds of the world*, 2nd edn. New York: Dover Publications.

Groombridge, B. (ed.). 1992 *Global biodiversity; status of the earth's living resources*. London: Chapman & Hall.

Harting, J.E. 1880 *British animals extinct within historic times*. London: Trubner & Co.

Hobbs, R.J. & Hopkins, J.M. 1988 From frontier to fragments: European impact on Australia's vegetation. In *Australian ecosystems; 200 years of utilisation, degradation and reconstruction* (ed. D. A. Saunders, A. J. M. Hopkins & R. A. How), pp 93–114. Chipping Norton, Australia: Surrey Beatty.

Inskipp, T. & Barzdo, J. 1987 *World checklist of threatened mammals*. Peterborough: Nature Conservancy Council.

King, W.B. 1981 *Endangered birds of the world: the I.C.B.P. red data book*. Washington, D.C.: Smithsonian Institution Press & ICBP.

Leigh, J.H. & Briggs, L. (ed.) 1992 *Threatened Australian plants: overview and case studies*. Canberra: ANPWS.

Margules, C.R., Nicholls, A.O. & Pressey, R.L. 1988 Selecting networks of reserves to maximise biological diversity. *Biol. Conserv.* **43**, 63–76.

Mathews, G.M. 1930 *Systema avium australasianarum. P II. Passerines*. London: British Ornithologists' Union.

Morton, S.R. 1988 The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. In *Australian ecosystems; 200 years of utilisation, degradation and reconstruction* (ed. D. A. Saunders, A. J. M. Hopkins & R. A. How), pp 201–213. Chipping Norton, Australia: Surrey Beatty.

Olson, S.L. & James, H.F. 1984 The role of the polynesians in the extinction of the avifauna of the Hawaiian Islands. In *Quaternary extinctions, a prehistoric revolution* (ed. P. S. Martin & R. G. Klein), pp. 768–780. Tucson: University of Arizona Press.

Perring, F.H. & Farrell, L. 1983 *British red data books. 1. Vascular Plants*. Lincoln: Royal Society for Nature Conservation.

Peters, J.L. 1931–1987 *Checklist of birds of the world*, vol. viii-xvi. Cambridge, Massachusetts: Museum of Comparative Anatomy.

Pratt, H.D., Bruner, P.L. & Berrett, D.G. 1987 *A field guide to the birds of Hawaii and the tropical Pacific*. Princeton University Press.

Pressey, R.L., Humphries, C.J., Margules, C.R., Vane-Wright, R.I. & Williams, P.H. 1993 Beyond opportunism: key principles for systematic reserve selection. *Trends Ecol. Evol.* **8**, 124–128.

Saunders, D.A., Hopkins, A.J.M. & How, R.A. (ed.) 1988 *Australian ecosystems; 200 years of utilisation, degradation and reconstruction*. Chipping Norton, Australia: Surrey Beatty.

Smith, F.D.M., May, R.M., Pellew, R., Johnson, T.H. & Walter, K.R. 1993*a* Estimating extinction rates. *Nature, Lond.* **364**, 494–496.

Smith, F.D.M., May, R.M., Pellew, R., Johnson, T.H. & Walter, K.R. 1993*b* How much do we know about the current extinction rate? *Trends Ecol. Evol.* **8**, 375–378.

Sohmer, S.H. & Gustafson, R. 1987 *Plants and flowers of Hawai'i*. Honolulu: University of Hawaii Press.

Stace, C. 1991 *New flora of the British Isles*. Cambridge University Press.

Strahan, R. (ed.) 1983 *Complete book of Australian mammals*. Sydney: The National Photographic Index of Australian Wildlife & Angus & Robertson.

Tyler, M.J. 1978 *The status of endangered Australian wildlife*. Adelaide: The Royal Zoological Society of South Australia.

Wagner, W.L., Herbst, D.R. & Sohmer, S.H. 1991 *Manual of flowering plants of Hawai'i*, vol. 1 & 2. Honolulu: University of Hawaii Press.

Woinarski, J.C.Z. & Braithwaite, R.W. 1990 Conservation foci for Australian birds and mammals. *Search* **21**, 66–68.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Discussion

N. J. Collar (*Birdlife International, Cambridge, U.K.*). The peak in recorded extinctions between 1850 and 1930 was attributed to man's plundering of habitats during this period. However, I think in reality it represents the shock wave from the accidental impacts of man's commensal species specificity on island faunas: the result of predation, competition and habitat modification by more aggressive continental animals such as rats, cats, dogs, pigs, monkeys and goats. If we were to eliminate island forms from the analysis, we would assuredly discover that the (continental) extinction rate is inexorably rising. This is the beginning of a second, far larger, wave, and this time it is undoubtedly caused by habitat destruction.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES