

1. Biological Diversity

16. SPECIES EXTINCTION

Species extinction is a natural process. The fossil record suggests that all species have a finite lifespan and that the vast majority of species that have ever existed are now extinct, with extinct species outnumbering living species by a factor of perhaps a thousand to one.

Species become extinct when all individuals die without producing progeny. They disappear in a different sense when a species lineage is transformed over evolutionary time, or divides into two or more separate lineages (so-called pseudo-extinction). The relative frequency of true extinction and pseudo-extinction in evolutionary history is unknown, although the former's great importance is demonstrated by the disappearance of entire, and once highly diverse, lineages such as trilobites and ammonites.

HOW SPECIES BECOME VULNERABLE TO EXTINCTION

Two broad categories of process are believed to affect the dynamics of populations, and provide the fundamental mechanisms of species extinction:

- deterministic processes (or cause and effect relationships) e.g. glaciation or direct human interventions such as deforestation
- stochastic processes (chance or random events), which may act independently or influence variation in deterministic processes.

The magnitude of the effects of these processes depends on the size and degree of genetic connectedness of populations. Four types of stochastic processes can be distinguished (Shaffer, 1987): *demographic uncertainty* (resulting from random events in the survival and reproduction of individuals); *environmental uncertainty* (due to unpredictable changes in weather, food supply, disease, and the populations of competitors, predators, or parasites); *natural catastrophes* (floods, fires or droughts); and *genetic uncertainty* (random changes in genetic make-up, to which several factors contribute).

Models of the effects of stochastic processes suggest that:

- demographic uncertainty is only a hazard for relatively small populations (numbering tens or hundreds of individuals)
- there is no critical population size that once reached guarantees a high level of long-term security from environmental uncertainty
- progressively larger increases in population size yield diminishing returns in persistence times for a given catastrophic event.

When demographic and environmental uncertainty interact, their effects compound each other, so that in a variable environment any loss in population size proportionally increases the chance of population extinction. Thus, to be reasonably certain of conserving a species for a significant length of time, one must preserve either very large population sizes (hundreds to millions of individuals or more, depending on the biology of the species) or numerous populations (Schaffer, 1987).

The isolation of populations

The 'equilibrium theory' of island biogeography developed by MacArthur and Wilson (1963 and 1967) is an extension of the species-area relationship (see Chapter 5). Whilst originally used to model species richness and turnover on real islands, it has subsequently been used to predict changes in species number in isolated habitat islands.

The area of an island sets an upper limit to the maximum population size of each species. Since small populations are inherently more prone to extinction than large (for reasons discussed above), extinction rates tend to be inversely proportional to island area. Successful colonisation by new species is not affected so much by area as by the degree of isolation of the island: islands near to the mainland or to other islands are colonised at higher rates than those farther away. Increased isolation of populations not only reduces the incidence of colonisation by new species, but decreases the probability that immigrants of an existing species will arrive. Over time, an equilibrium is eventually reached on any island at which the loss of species through extinction is balanced by the arrival and colonisation of new species.

A later modification of the theory incorporates the 'rescue effect' (Brown and Kodric-Brown, 1977). The immigration of new, unrelated individuals can play an important role in maintaining an isolated population, because their demographic and genetic contributions tend to increase its size and genetic fitness, thereby reducing the possibility that it will become extinct. The significance of the rescue effect is that fewer immigrants are needed to rescue an existing population than to successfully found a new one.

Island biogeographic theory has far-reaching implications for conservation biology. Rates of habitat modification are currently so high that virtually all natural terrestrial habitats and protected areas are destined to become ecological 'islands' in surrounding 'oceans' of habitat much altered by human activity. Not only is the total area of many natural habitats rapidly decreasing, but those large natural habitat islands that now exist are being fragmented into archipelagos of habitat islands. This process of fragmentation and isolation is predicted to lead directly and indirectly to accelerated species extinctions at both the local and global scales.

Consequences of insularisation

The combination of short- and long-term insularisation effects is predicted to reduce the number of species to a lower equilibrium. A study of understorey birds in fragments of tropical forest ranging from 0.1 to 571ha in the Usambara Mountains, Tanzania, found just this result (Newmark, 1991). Since separation, smaller forest fragments have lost more bird species than larger areas, and more isolated fragments have lost more species than those close to a source of potential colonists. Similarly, Klein (1989) observed communities of dung and carrion beetles (subfamily Scarabaeinae) in fragmented habitat patches of different sizes in the Amazon rain forest of Brazil. He found that forest fragments had lower species richness, an

(1989) observed communities of dung and carrion beetles (subfamily Scarabaeinae) in fragmented habitat patches of different sizes in the Amazon rain forest of Brazil. He found that forest fragments had lower species richness, an increased proportion of rare species, and sparser populations in comparison with continuous undisturbed forest. These differences were more pronounced in small fragments (<1ha) than large.

Many researchers, however, are now convinced that calculation of rates of species loss in habitat islands or reserves using the species-area relationship is unjustified as a basis for detailed conservation recommendations. Boeckeln and Gotelli (1984) argue that the models developed ignore species identity, habitat heterogeneity and population sizes, and have such wide margins of error that they have low explanatory power and give unreliable estimates. For example, Soulé *et al.* (1979) predicted on the basis of a simple species-area model that the Serengeti National Park will lose 50% of its large mammals (some 15 ungulate species) in the first 250 years of isolation, while Western and Ssemakula (1981) attempted to incorporate habitat diversity data and predicted that only one species will be lost. Zimmerman and Bierregard (1986) argue that beyond the ecological truism that species richness increases with area, the equilibrium theory of biogeography has revealed little that is of "real value for planning real reserves in real places". In designing reserves to protect Central Amazonian forest frogs, Zimmerman and Bierregard consider that critical breeding habitat and places that contain quality habitat at high density must be found before the reserve size question is addressed. In general, biologists need empirical studies that directly measure the effects of habitat fragmentation on specific groups (Klein, 1989).

Ecological correlates of vulnerability to extinction

There is considerable evidence that the number of species in an isolated habitat will decrease over time, although the probable rates of such extinctions (and whether the equilibrium theory of island biogeography can be used to predict these) are in dispute. The crucial issue for conservationists now is whether those species which are most at risk from extinction following habitat fragmentation can be predicted from a knowledge of their biology and ecology. At least nine ecological or life history traits (some of which may actually be highly correlated with each other) have been proposed as factors determining an animal species sensitivity to fragmentation (Karr, 1991; Laurance, 1991):

Rarity

Several studies have found that the abundance of a species prior to habitat fragmentation is a significant predictor of extinction. For example, Newmark (1991) found that after fragmentation, rare understorey bird species occupied fewer forest fragments per species than common ones. This is only to be expected, since fewer individuals of a rare species than a common species are likely to occur in habitat fragments, and the mechanisms of extinction mean that small populations are inherently more likely to become extinct than large.

Dispersal ability

If animals are capable of migrating between fragments or between 'mainland' areas and fragments, the effects of small population size may be partly or even greatly mitigated by the arrival of 'rescuers'. Species that are good dispersers may therefore be less prone to extinction in fragmented habitats than poor dispersers.

Degree of specialisation

Ecological specialists often exploit resources which are patchily distributed in space and time, and therefore tend to be rare. Specialists may also be vulnerable to successional changes in fragments and to the collapse of coevolved mutualisms or food webs.

Niche location

Species adapted to, or able to tolerate, conditions at the interface between different types of habitats may be less affected by fragmentation than others. For example, forest edge species may actually benefit from habitat fragmentation.

Population variability

Species with relatively stable populations are less vulnerable than species with pronounced population fluctuations, since they are less likely to decline below some critical threshold from which recovery becomes unlikely.

Trophic status

Animals occupying high trophic levels usually have small populations: e.g. insectivores are far fewer in number than their insect prey and, as noted above, rarer species are more vulnerable to extinction.

Adult survival rate

Species with naturally low adult survival rates may be more likely to become extinct, as Karr (1991) has proposed for island birds on Barro Colorado Island, Panama.

Longevity

Long-lived animals are less vulnerable to extinction than short-lived.

Intrinsic rate of population increase

Populations which can expand rapidly are more likely to recover after population declines than those which cannot.

Laurance (1991) has, however, studied extinction proneness among 16 species of non-flying land mammals in fragmented rain forest in Queensland, Australia. Seven traits were examined: body size, longevity, fecundity, trophic level, dietary specialisation, natural abundance in continuous rain forest, and 'matrix' abundance (abundance of the species in modified habitats surrounding original fragments). Of these, matrix abundance was the best predictor of vulnerability. Once its effects were removed, partial correlations showed no other significant predictors of extinction proneness.

Laurance therefore suggests that tolerance of modified habitats is important in determining survival in fragmented habitats. Species that were able to exploit modified habitats tended to remain stable or even to increase in number in

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fragments, whereas those that avoided these habitats tended to disappear. The most vulnerable species even avoided using the corridors of secondary growth forest that existed along streams, a finding which highlights the importance of maintaining corridors of primary vegetation to act as pathways for dispersing individuals between patches of habitat.

Viable populations, genetic variation and extinction

Increasingly the attention of conservationists has become focused on the management and preservation of isolated small populations confined to habitat islands, usually in protected areas. An essential requirement is to ascertain how many individuals of a species should be conserved in order to ensure its survival in a particular area. There are two approaches to estimating such a Minimum Viable Population (MVP) size, the demographic and the genetic. The process of applying a demographic or genetic MVP model to a particular species or population, and proposing the management interventions that should be undertaken to increase its chances of survival, is known as Population Viability Analysis (PVA).

In the demographic approach, estimates of a population's average growth rate (which is in part determined by the species's body size), the variance in this growth rate attributable to environmental fluctuations, and the population's maximum size, are used in mathematical models to calculate its expected persistence time to extinction. There are two main factors that need to be considered: the population size, and the length of time it requires to be preserved. Normally, an MVP is taken to be that size of population that has a 95% probability of persistence for x number of years, where for consistency x is usually taken as either 100 or 1,000.

Clearly, there is no such thing as a standard MVP that can be applied to all species. Belovsky (1987) has calculated that over a range of body masses from 10g (the size of a European Common Shrew *Sorex araneus*) to 10^6 g (the size of a Black Rhinoceros *Diceros bicornis*), MVP sizes for mammals range from hundreds to millions. The Minimum Area Required (MAR) to support these populations ranges from tens to millions of square kilometres. As body mass increases, MVP size decreases, but larger mammals require proportionately larger ranges. MARs are larger for carnivores than for herbivores and larger for tropical than for temperate species.

MVPs can also be examined from a genetic perspective, in which not only the number of individuals surviving but their genetic variation or heterozygosity are considered important. In the long term, this genetic variation is necessary for evolution by natural selection to occur, and is required for adaptation to potential future changes in the environment. In the short term, heterozygosity is positively correlated with fitness, including survival, disease resistance, growth and developmental rate and stability (Allendorf and Leary, 1986).

Genetic variation can quickly be lost through breeding with closely-related individuals (inbreeding) which leads to low levels of heterozygosity and lowered offspring fitness, a

phenomenon known as inbreeding depression (Falconer, 1981). The most likely explanation is that new mutations, which are almost always harmful, can accumulate in a species genome providing they are fully or partially recessive and are not therefore expressed. Inbreeding increases the probability that the effects of these harmful genes will be expressed.

Franklin (1980) has proposed that in the short term an effective population size of 50 is the MVP required to guard against the negative effects of inbreeding for a population of large mammals with no immigration or introduction of unrelated stock. Populations of this size will nevertheless eventually become inbred over time, to a degree directly related to the generation interval (randomly-breeding populations of 50 mice will become more inbred in a decade than 50 elephants will in a century). In the long term an effective population size of 500, corresponding to a real population size of several times this number, has been suggested as a suitable genetic MVP for large mammals, since in a population of this size rates of mutation will renew genetic variation as quickly as it is lost by inbreeding and genetic drift (Franklin, 1980; Lande and Barrowclough, 1987).

Although biologists have suggested the figures quoted above as useful first estimates of MVP sizes, in both the demographic and the genetic approach the actual numerical value arrived at depends not only on the criteria chosen to define the MVP (e.g. the number of years the population is required to persist) but also on the values of the parameters used in the model. These values cannot always be assigned in an objective manner. Thus even for one particular species there is no single number that is universally valid, and this reservation is doubly true when different species are compared. Each situation is unique and should be considered separately. For example, a species that exhibits a boom and crash population cycle will require a larger MVP than one which inhabits a stable environment and whose population is relatively stable.

Both MVPs and PVAs have now been applied to a variety of species. Examples include: large mammals such as the Sumatran Rhinoceros *Dicerorhinus sumatrensis* and the Florida Panther *Felis concolor coryi*; and birds such as the Bali Starling *Leucopsar rothschildi*, Caribbean parrot species, and Asian Hornbills.

Analysis of the existing worldwide protected areas system indicates that few if any large mammal species will be adequately conserved with the current scale of ecosystem coverage, as most protected populations are too small to constitute MVPs (Grumbine, 1990).

The fact that a population has declined in number to below the theoretically determined MVP does not automatically mean that its situation should be considered hopeless. Some species, such as the Northern Elephant Seal *Mirounga angustirostris* (Bonner and Selander, 1974) and captive populations of Golden Hamster *Mesocricetus auratus* have survived through population bottlenecks of just a few individuals, following which numbers have increased to substantial levels. Eventually, if a large population is re-established, genetic variation may be regenerated by mutation, thus restoring the potential for adaptive evolution.

These examples, however, may be the exceptions rather than the rule. Other species that have declined to such low levels may have vanished altogether. Even if populations do recover numerically from a bottleneck, inbreeding and consequent loss of heterozygosity may cause noticeable declines in fitness effectively prejudicing the species long-term chances of survival. For example, O'Brien *et al.* (1985) found high rates of juvenile mortality, incidence of sperm abnormalities, and susceptibility to disease in several populations of Cheetah *Acinonyx jubatus*, and attributed this to the low level of genetic variation found in all Cheetah populations examined.

Perhaps the most compelling evidence to date of the negative consequences of population bottlenecks comes from a study of Lion *Panthera leo* in Ngorongoro Crater and the neighbouring Serengeti Plains in Tanzania. In 1962 the relatively isolated Lion population in the Crater dropped from around 70 individuals to 10 as a result of an outbreak of biting flies *Stomoxys calcitrans*. The population has since recovered to its pre-plague levels. Packer *et al.* (1991) have found that compared to the larger outbred population of Serengeti Lions, those in Ngorongoro suffer high levels of sperm abnormality. Their reproductive performance has also diminished over the years since the bottleneck, and both effects are apparently correlated with the lower levels of heterozygosity in the Ngorongoro population.

Metapopulation theory

The MVP models discussed so far have considered all individuals as belonging to a single isolated population, which is rarely the case in the real world. In practice most species are patchily distributed, and are best regarded as a population of subpopulations, or a *metapopulation*, in which subpopulations are geographically isolated but interconnected by patterns of gene flow, extinction and recolonisation. Thus, studies over a 25-year period by Erhlich and colleagues of a purported single population of Checkerspot Butterfly *Euphydryas editha bayensis* in the Jasper Ridge Preserve (USA) demonstrated that although the population occupied three nearly contiguous habitat patches, it actually consisted of three demographic units whose sizes fluctuated independently in response to annual changes in rainfall. One of these units became extinct, was re-established by immigration, and became extinct again several years later (Wilcox and Murphy, 1985). Relaxing the single population assumption of the MVP model so that immigrants can be received from neighbouring populations will lengthen the projected persistence times.

Habitat heterogeneity and the existence of many subpopulations are an important element of population dynamics, and have profound implications for conservation biology. Pulliam (1988) introduced a simple model of metapopulation dynamics incorporating density-dependent immigration as the linking factor between source and sink populations in severely fragmented habitats. In his model, a limited number of reproductively successful 'source' subpopulations produce an excess of offspring over and above the number that the habitat can absorb. The surplus individuals migrate to other less favourable areas, occupied

by 'sink' subpopulations which would be doomed to extinction without persistent immigration.

Supporting evidence for the source-sink metapopulation theory is available from a number of field studies; for example, King and Mewaldt (1987) found that isolated montane populations of White-crowned Sparrows *Zonotrichia albicollis* were unable to persist without periodic immigration.

Metapopulation theory should help biologists determine which populations are priorities for conservation. The importance of identifying and preserving source populations and habitats is obvious: without them the metapopulation cannot persist. However, the presence of breeding individuals at a particular site does not necessarily indicate that it is suitable for the species in the long term, since it could still be a sink habitat. In general, source populations will not only have higher annual reproduction rates than annual mortality rates but will also have more stable populations than sink populations. In the case of long-lived species the identification of source populations will therefore necessitate continuous, long-term monitoring. In addition to the identification and protection of demographic source populations, the conservation of buffer habitats and marginal subpopulations should also be a part of comprehensive conservation plans, and the long-term status of even apparently secure metapopulations should be carefully monitored.

Conclusion

Current models of the extinction process and estimates of habitat loss, principally tropical forest, predict that species extinctions are occurring at very high rates on both a local and global scale. The primary cause is habitat modification and fragmentation by human activities. This process not only decreases overall population sizes of many species but splits previously continuous populations into smaller isolated sub-populations. Deterministic and stochastic effects mean that small populations are more susceptible to extinction than large. Conservation biologists have enlisted the help of various theories and models to try and predict how many species, and which ones, will be lost. It is possible to make reasonable predictions of which species will be most adversely affected by habitat fragmentation.

The species-area relationship is not now thought to be a good predictor of species loss in habitat fragments, but has implications for the design and positioning of reserves. With a realisation that ecosystems are often best preserved by concentrating on keystone species, efforts have switched to conducting population viability analyses for selected species in an attempt to estimate the minimum viable population sizes that must be conserved to ensure their long-term survival. MVPs can be examined from either the demographic or genetic perspective - both approaches give estimates of a similar order of magnitude. A shortcoming of MVP estimates is that they consider only a single population. The incorporation of metapopulation theory should improve the accuracy and utility of these models, and allow the identification of the most important

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subpopulations, facilitating the determination of conservation priorities.

A BRIEF HISTORY OF EXTINCTIONS

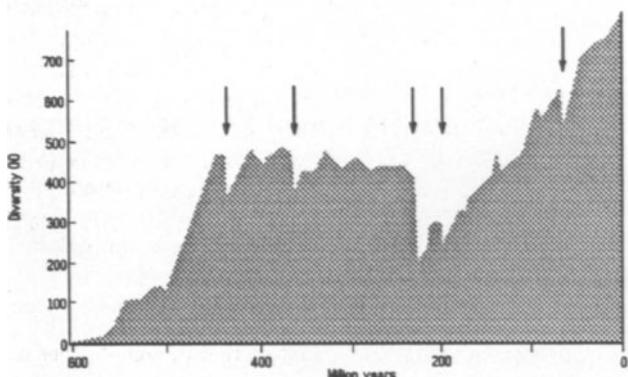
Knowledge of extinction patterns through geological time is based on analysis of the fossil record, which represents a small and highly biased sample of the taxa that have existed - it may represent only one in every 20,000 species that has existed. The best preserved group consists of marine animals, chiefly invertebrates, with durable, highly mineralised exoskeletons. Caution has to be exercised in extrapolating from this group to others, particularly plants, as they may show different patterns of extinction.

Mass extinction events in marine organisms

The fossil record indicates that overall extinction rates have not been constant over time (Fig. 16.1). Around 60% of extinctions have occurred in a number of relatively short episodes. The earliest period for which there is evidence of a major loss of diversity is during the late Precambrian, around 700 Mya (million years ago) although the Precambrian fossil record is too incomplete to allow detailed analysis.

The fossil record for the Phanerozoic (i.e. from the Cambrian to the present, see Fig. 16.2) is much more detailed. During this time there have been five major 'mass extinction events'. These events took place late in each of the Ordovician, Devonian, Permian, Triassic and Cretaceous periods. By far the most severe was in the late Permian (245 Mya). At that time, the number of families of marine animals recorded in the fossil record declined by 54% and the number of genera by 78-84%. Extrapolation from these figures indicates that species diversity may have dropped by as much as 96%. The second most severe mass extinction, at the end of the Ordovician (440 Mya), resulted in the loss of 22% of families of marine taxa, a slightly

Figure 16.1 Extinction events in marine organisms



Source: Modified from Erwin, D.H., Valentine, J.W. and Sepkoski, J.J. 1987. A comparative study of diversification events: the early Palaeozoic versus the Mesozoic. *Evolution* 41(6).

Note: The curve plots diversity of marine animal families and indicates five major extinction phases.

Figure 16.2 The geological time scale

Era	Period	Millions of years ago
Cenozoic	Quaternary	2
	Tertiary	66
	Cretaceous	138
	Jurassic	195
	Triassic	245
	Permian	290
	Carboniferous	345
	Devonian	400
	Silurian	440
	Ordovician	500
Camrian		580

Note: Dates are approximate; scale covers the Phanerozoic only.

greater figure than the late Devonian and late Triassic events (21% and 20% respectively). The late Cretaceous event was the least important, resulting in the loss of around 15% of marine families.

The causes and timespans of these events have been the subject of much debate and study. It is now widely accepted that the late Permian mass extinction was a long-term event, lasting for 5-8 million years. It appears to have been associated with geologically-rapid global physical changes (including the formation of the supercontinent Pangea), climate change, and extensive, tectonically-induced marine transgression and increased volcanic activity. There is no direct evidence of a single, catastrophic event such as impact by an extra-terrestrial body, although this cannot be

ruled out as a contributory factor in the event. Interpretation of the late Triassic event is hampered by the absence of a good stratigraphic record; some indications suggest this was also a protracted period of extinction, although this is uncertain. The late Devonian extinction also appears to have spanned a considerable length of time, with elevated extinction rates throughout much of the middle and late Devonian. However, this extinction phase probably consisted of a series of discrete shorter extinction events rather than one protracted episode.

In contrast to these, the late Ordovician and late Cretaceous extinctions are thought to have taken place over a much shorter period. The late Ordovician event appears to be correlated with global glaciation 439 Mya (the Hirnantian glaciation) with three separate episodes of extinction spread over only 500,000 years.

The late Cretaceous extinction is probably the best known, but in terms of overall loss of diversity is also the least important. There is some evidence that this extinction event was associated with an extra-terrestrial impact, although this remains controversial.

As well as these major mass extinction events, a large number of less dramatic, but still significant, episodes can be identified from the marine fossil record. It has been argued that those following the late Permian extinction event have a periodicity of 26–28 million years, indicating some underlying unifying cause, although this remains unproven. It is notable that these more minor events account in total for more extinctions than the five major events outlined above.

Mass extinctions in vertebrates

The vertebrate fossil record, especially for terrestrial tetrapods, is much less amenable to analysis of extinction rates than the invertebrate record chiefly because it is less complete and less diverse. However, studies indicate that tetrapods have been subject to at least six mass extinction events since their appearance in the late Devonian, while fishes have experienced eight such events since their recorded origin in the Silurian. Some of these events coincide with each other and with those recorded for marine invertebrates; in particular, the five major mass extinction events outlined above are paralleled by losses in vertebrate diversity. The most significant is the late Permian event, which is the largest recorded extinction both for fishes (44% of families disappearing from the fossil record) and tetrapods (58% of families disappearing). The late Cretaceous event was more significant for tetrapods than for other groups, with 36 of the 89 families in the fossil record disappearing at this time. These families were, however, virtually confined to three major groups which suffered complete extirpation – the dinosaurs, plesiosaurs and pterosaurs. Most other major vertebrate taxa were almost completely unaffected.

Evidence for correlation between the more minor extinction events in vertebrates and the postulated periodic extinctions in marine invertebrates is currently poor.

Extinctions in vascular plants

In general, the plant fossil record does not clearly show the same sudden mass-extinction events seen in the animal record. Part of the explanation for this may lie in the nature of the plant fossil record itself and in the difficulties in interpreting it, but there also seem likely to be genuine differences between plants and animals in patterns of species origination and extinction. Plant extinction rates (based on analysis of families and genera) do vary with time, but in general, periods of elevated plant extinction appear to be more protracted than animal extinction events and do not usually coincide with them. It is argued that these periods may be more to do with competitive displacement by more developed plant forms, or with gradual climatic change, than with any sudden catastrophic events (Knoll, 1984).

The major exception to this is the end-Cretaceous catastrophe, which appears to have had a major influence on the structure and composition of terrestrial vegetation and on the survival of species. Data from fossil leaves suggest that perhaps 75% of late Cretaceous species became extinct, although data from fossil pollens indicate a lower though still significant level of extinction. During the Tertiary there are two other periods of widespread enhanced extinction rates, during the late Eocene and from the late Miocene to the Quaternary, although in the latter, extinction of taxa at generic level and above appears to have been mainly regional rather than global.

Background extinction rates

A corollary of the finding that the majority of extinctions recorded in the fossil record have taken place over relatively short time periods (geologically speaking) is that extinction rates for the remainder of the Phanerozoic have been low.

The average lifespan of species in the fossil record is around four million years which would give, at a very gross estimate, a background extinction rate of four species each year out of a total number of species of around 10 million. However, it can be argued that the fossil record is heavily biased towards successful, often geographically wide-ranging, species which undoubtedly have a far longer than average persistence time. Most species will therefore survive for less than four million years, and real extinction rates at any given time will be correspondingly higher. Nevertheless, even if background extinction rates were ten times higher than this, extinctions amongst the 4,000 or so living mammals would be expected to occur at a rate of around one every 400 years, and amongst birds at one every 200 years.

It is indisputable that the extinction rate in recent times has been far higher than this and that man has been the overwhelming cause. It is also widely accepted that mankind is in danger of precipitating further extinctions on a scale and at a rate at least comparable with those of the major extinction events in the distant past.

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Extinctions and the spread of mankind

Documenting man's impact on the world's biota, and in particular quantifying species extinctions induced by man, is difficult for a variety of reasons, associated with: identifying species, especially those known only from sub-fossil or fossil remains; unequivocally demonstrating that extinction has occurred; and establishing a causal link between man's activities and extinction of the species in question.

Man may have first had a significant impact on the survival of other species during the late Pleistocene. Humans spread into Europe and Asia about one million years ago but slow advances in culture and technology seem to have restricted the impact on the fauna of these regions. However, man's arrival on previously isolated continents, around 50,000 years ago in the case of Australia and 11,000 years ago for North and South America, seems to coincide with large-scale extinctions in certain taxa. The exact timings are unclear and hence the cause and effect in each case are open to debate. However, Australia lost nearly all its species of very large mammals, giant snakes and reptiles, and nearly half its large flightless birds around this time. Similarly, North America lost 73% and South America 80% of their genera of large mammals at around the time of the arrival of the first humans. In these cases there is more direct evidence to link the events, although climatic upheavals at around the same time could also be implicated.

EXTINCTIONS IN RECENT HISTORY

The European Age of Expansion in the 15th and 16th centuries initiated another wave of extinctions. Indeed it has often been assumed that all, or at least the great majority, of modern man-induced extinctions date from this period. However, this may well be based more on the fact that a dramatic increase in documentation of natural phenomena, in large measure induced by the great voyages of discovery, also dates from this time.

It is now known that in some parts of the world a significant number of extinctions occurred before the arrival of Europeans. The Polynesians, who colonised the Hawaiian Islands in the 4th and 5th centuries AD, appear to have been responsible for exterminating around 50 of the 100 or so species of endemic land birds in the period between their arrival and that of the Europeans in the late 18th century. A similar impact seems to have been felt in New Zealand, which was colonised some 500 years later than Hawaii. Here an entire avian megafauna, consisting of members of the family Anomalopterygidae (the Moas) was apparently exterminated, also by the end of the 18th century. As with the late Pleistocene extinctions, there has been some controversy over the extent to which humans were responsible; however there is now a broad consensus that man was indeed responsible, probably through a combination of direct hunting and large-scale habitat destruction through burning.

Although most information from this period relates to avian extinctions, there is evidence that other groups, particularly mammals, had been similarly affected. On Madagascar, in addition to 6-12 ratites, including the Giant Elephantbird

Aepyornis maximus (the largest bird ever recorded), at least 14 lemur species, most of them larger than any surviving species, have become extinct within the last 1,500 years, as have two giant tortoises. In the Caribbean, at least two ground sloths in the family Megalonychidae, several large rodents and three insectivores in the family Nesophontidae survived into the period of Amerindian settlement, but had become extinct before Europeans arrived at the end of the 15th century. The case for man being solely responsible for these extinctions is more equivocal than it is for New Zealand. However, on balance this appears to remain the most likely explanation, although it is possible that, on Madagascar at least, climate change leading to progressive desiccation of the environment also played a part.

While documentation has improved considerably since the 15th and 16th centuries, it still remains far from complete. This applies even to the best known groups, namely birds and mammals; for most lower vertebrates and virtually all invertebrates knowledge of extinction rates remains extremely scanty.

The main problem for documentation is that the majority of the world's species, especially tropical invertebrates, have not been scientifically named. A significant percentage of these may well become extinct before they have ever been collected and described. Of described taxa, numbering around 1.1 million animal species and around 270,000 vascular plants, accurate information on status and abundance is available for only a tiny proportion. The vast majority of the world's species, even in the best-known groups such as mammals and birds, are not subject to systematic monitoring and species may be locally or completely extirpated before their plight becomes known.

In general, it can only be stated with any confidence that a taxon is extinct when unsuccessful attempts have been made to locate it, or when it has not been sighted for several decades. Animal species thought to have become extinct, using this criterion and expert opinion, are listed in Table 16.1. Even here it is often difficult to demonstrate unequivocally that a species has become extinct and consequently several species are marked as possibly still being extant. Many species may persist unrecorded (albeit often in very low numbers) despite intensive efforts to locate them. This is borne out by the periodic reappearance of 'Lazarus taxa', after many years or decades of presumed extinction. Plants (Table 16.2), some of which produce seeds that can lie dormant and undetected for many years before germination, present particular monitoring problems.

Historical records of extinctions may thus be expected to be heavily biased, both taxonomically and geographically. Taxonomically, information on snails, particularly terrestrial species, birds and mammals is good, while that for most other groups is poor. Geographically, information on Europe and North America (including Hawaii) is much better than that for the rest of the world, although relatively few species extinctions have been recorded in Europe in recent times. Figures 16.6-16.10, taken from Table 16.6, illustrate these biases.

These biases make analysis of extinction patterns problematic. However, certain generalised patterns do

Table 16.1 Summaries of animal extinctions on islands and continents

	MOLLUSCS	BIRDS	MAMMALS	OTHER	TOTAL
ISLANDS	151	104	34	74	363
% of islands total	41.6	28.7	9.4	20.4	100
% of grand total	31.2	21.5	7	15.3	75
CONTINENTS	40	11	24	46	121
% of continents total	33.1	9.1	20	38	100
% of grand total	8.3	2.3	5	9.5	25
TOTALS	191	115	58	120	484
% of total on islands	79	90.4	59	61.7	75
% of TOTALS	39.5	23.8	12	24.8	100

emerge. The most important of these is the preponderance of extinctions on islands over those in continental areas (Table 16.1). Exactly 75% of recorded animal extinctions since 1600 have been on islands. For the three groups with best information, the proportion of island extinctions varies from 90% for birds to 58% for mammals, with molluscs intermediate at 80%. Of the continental extinctions, at least 66% can be classified as aquatic species (this includes amphibians and insects with aquatic larval stages but excludes birds such as ducks and grebes). Most striking, perhaps, is the very small number of extinctions recorded to date in continental tropical forest ecosystems, which are precisely the areas where mass extinction phenomena are predicted to be taking place at present (see below).

There appear to be several reasons for the elevated extinction level amongst island species. Most straightforwardly, island species, especially those confined to single islands, tend to have very restricted and completely circumscribed ranges: they consist effectively of single populations. Adverse factors are thus likely to affect the entire species and bring about its extinction. In contrast, continental species tend to occupy larger ranges existing as meta-populations, with a number of more-or-less isolated subpopulations. It is likely that some of these subpopulations will not be affected by a given adverse factor. Thus, the species itself will survive even if a number of subpopulations are extirpated. These concepts apply both to real islands and ecological islands, that is, areas of habitat separated from other such areas by inhospitable environments which act as an effective barrier to dispersal. In this context, aquatic species in isolated inland waters behave similarly to terrestrial species on isolated oceanic islands, which helps to explain the significantly elevated number of extinctions amongst continental freshwater species.

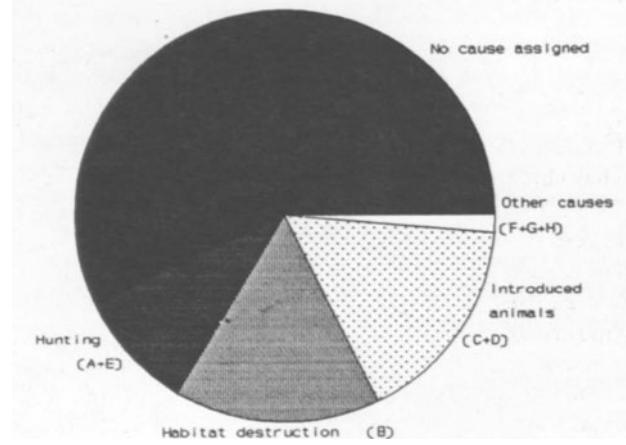
Many island species are innately vulnerable to extinction because of their biology. Species on islands have often evolved in the absence of terrestrial predators and may therefore be highly vulnerable to introduced predators. Tameness, flightlessness and reduced reproductive rates characterise many island birds and appear to have been major contributory factors in their extinction, through predation by humans or introduced species. Similarly, many island land snails, such as the Hawaiian *Achatinella* and French Polynesian *Partula* species, have low reproductive rates and, apparently, no defences against introduced

predators, most notably the snail *Euglandina*. The elevated species extinction rates on islands can also be ascribed to taxonomic practices, as there has been a tendency for island populations to be designated as full species when they may more reasonably be regarded as subspecies of species on adjacent islands or on the mainland.

Causes of Extinction

A brief analysis of the 'Possible causes' column of Table 16.4 shows that introduced animals and direct habitat destruction by man have been major factors involved in these extinctions, being implicated in 17% and 16% respectively (see Fig. 16.3). These are equivalent to 39% and 36% if only those extinctions for which causes are assigned are counted. Hunting and deliberate extermination also contribute significantly (23% of extinctions with known cause). For a large number of animals, no information on cause of extinction was known.

Figure 16.3 Causes of animal extinction



Notes: These figures were compiled by giving each species a score of 1 in the appropriate category if there was only one cause, 0.5 in each for two, etc. Where there were multiple causes C/D was counted as one part, C and D as two parts.

Time Series

Figures 16.4 and 16.5 and Table 16.2 present a breakdown of recorded extinctions in 30-year intervals from the year

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Table 16.2 Time series of animal extinctions on islands and continents

	ISLANDS					CONTINENTS					COMBINED	
	MOLLUSCS	BIRDS	MAMMALS	OTHER	TOTAL	MOLLUSCS	BIRDS	MAMMALS	OTHER	TOTAL	TOTAL	
TOTALS	151	104	34	74	303	40	11	24	46	121	484	
1600–1629	0	2	0	1	3	0	0	0	0	0	3	
1630–1659	0	4	0	1	5	0	0	0	0	0	5	
1660–1689	0	9	0	0	9	0	0	0	0	0	9	
1690–1719	0	5	0	2	7	0	0	0	0	0	7	
1720–1749	0	4	0	0	4	0	0	0	0	0	4	
1750–1779	0	10	1	0	11	0	0	0	0	0	11	
1780–1809	0	2	0	4	6	0	0	1	0	1	7	
1810–1839	0	8	0	1	9	0	1	2	0	3	12	
1840–1869	2	9	2	3	16	0	1	1	1	3	19	
1870–1899	67	16	3	4	90	0	1	6	1	8	98	
1900–1929	11	19	3	18	51	6	4	3	7	20	71	
1930–1959	37	10	2	6	55	25	2	7	15	49	104	
1960–	9	5	3	7	24	4	2	2	12	20	44	
No date	25	1	20	27	73	5	0	2	10	17	90	

Note: these summaries do not take into account 4 species (2 birds, 1 mammal and 1 'other') which are not assignable to either island or continent.

1600. These data should be interpreted cautiously. In only a few cases are the extinction dates reasonably certain; more often they are approximate to within one or two decades. In other cases, they are simply the date when the species was last recorded, and it is unknown how accurately they reflect the actual date of extinction (assuming the species is truly extinct). The uncertainties are most marked for species in areas which have only been occasionally surveyed (e.g. land snails on many tropical islands), and create difficulty in interpreting trends in extinction rates.

Of the individual taxa presented, island birds are the best documented group. There is no consistent trend over the full 400 years; peaks occur in the mid-17th and mid-18th centuries, and there is a clearer increase for the early 19th century until the 1930s. The apparent fluctuations for the first 200 years may represent real effects from introduced species, hunting and habitat modification associated with increasing levels of human settlement. Continental bird extinctions and the entire mammal data set are numerically smaller and thus harder to interpret. Of the 14 dated mammalian extinctions on islands, 13 have taken place since 1840. Most of the 20 undated mammalian extinctions (chiefly Caribbean rodents and insectivores) are believed to have taken place before the middle of the 19th century, showing little indication of a marked overall trend.

Information on mollusc extinctions was not available prior to the mid-19th century, and although high numbers of extinctions are documented for island molluscs in two 30-year periods, uncertainty in the dates again confuses interpretation.

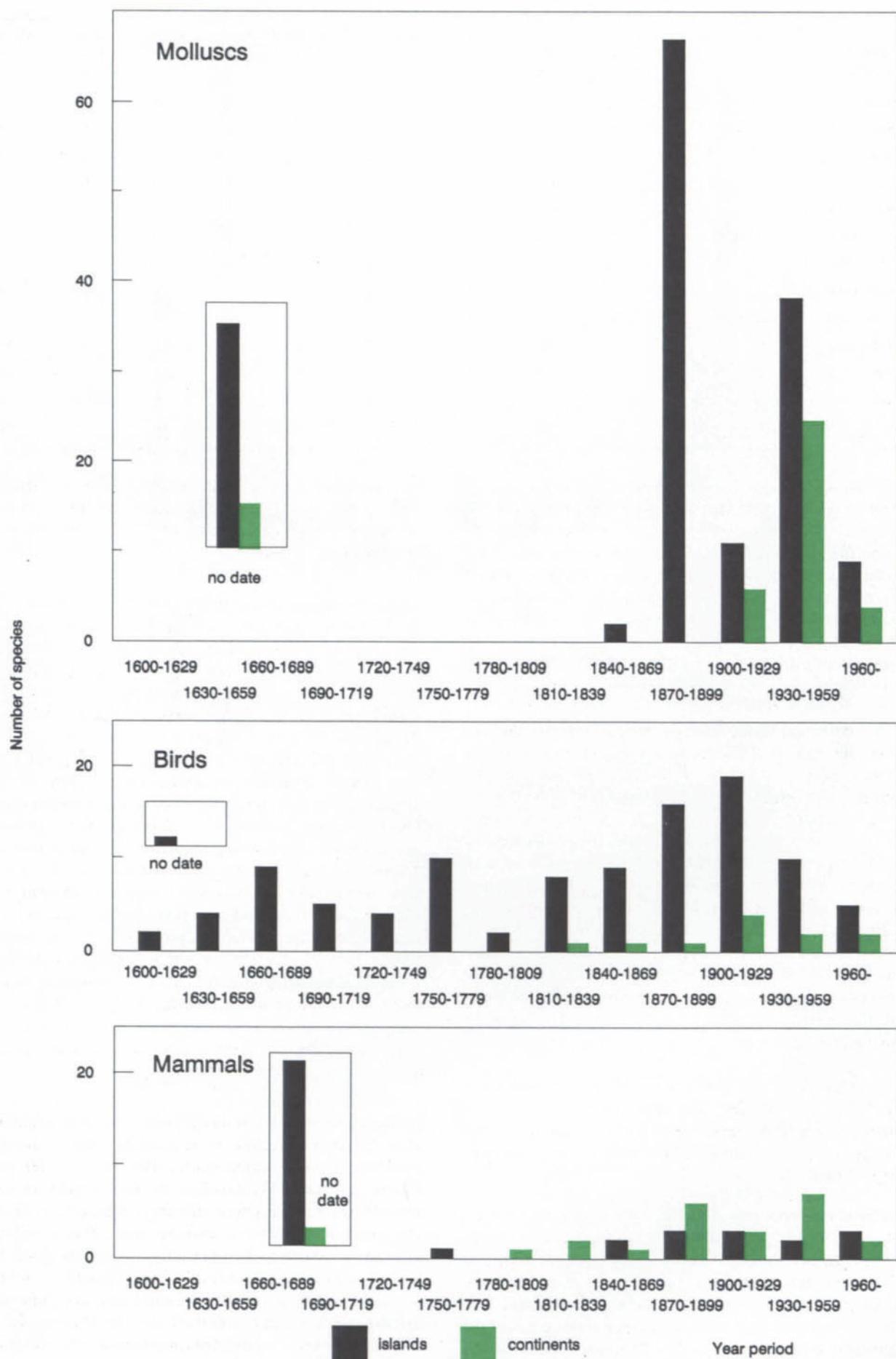
Two trends are apparent in the time-series data for all taxa: first, that documented island extinctions began almost two centuries earlier than continental extinctions; second, that both island and continental extinctions have increased rapidly from early or mid-19th century to the mid-20th century. This increase has been more pronounced for continental species, although the island extinctions exceed

continental ones numerically in all periods. The late 19th century for islands has the highest rate of all periods, reflecting a high contribution for mollusc extinctions on islands during this period.

The apparent decline in rate for both continental and islands for 1960-1989 is probably attributable to two causes; one is the expected time-lag in recording extinctions from 1960 onwards. As noted above, extinction is normally only attributed when a species has not been recorded over a significant time span. For some purposes, such as the designation of 'Extinct' under the Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES), this time period is arbitrarily taken as 50 years. By this criterion, therefore, no species would be accepted as having become extinct since 1960 as 50 years would not have elapsed since its last being recorded. A more realistic and flexible approach has been adopted here, on the grounds that some species recorded since 1960 are regarded with a high degree of certainty to have become extinct, while conversely many species not observed by specialists in the wild for over 50 years are almost certainly still extant. Nevertheless, the general principle holds that the longer a species has not been recorded the more likely it is to be regarded as extinct, and vice-versa. A significant number of species are therefore likely to have become extinct recently without being recorded as such.

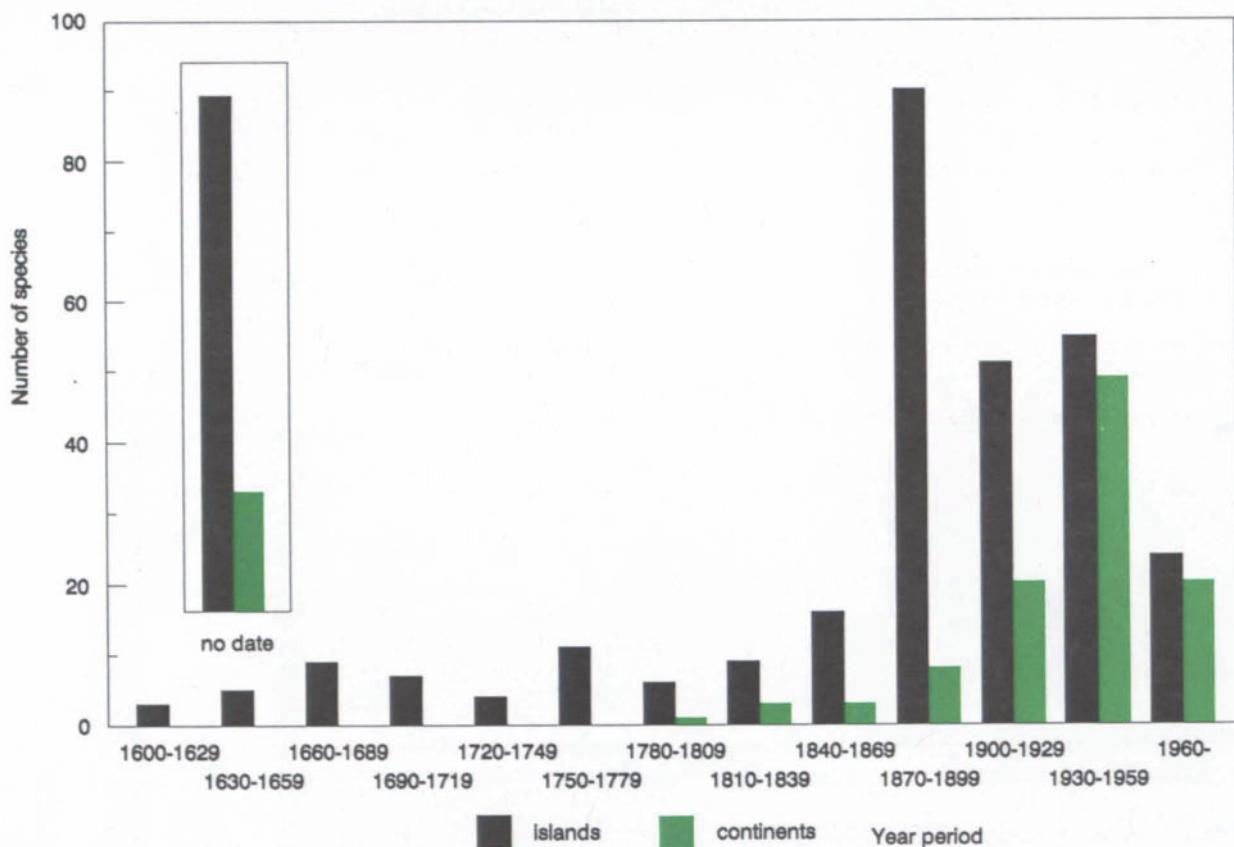
A second, more positive contributory factor to explain the apparent recent decline in extinction rates is the great increase in conservation action over the past 30 years. During this time, attention has focused largely on saving well-known species under imminent threat of extinction; most efforts to preserve these species have succeeded, at least in the short or medium term. Several projects have taken the last wild individuals into captivity to build up populations until environmental conditions and populations are suitable for re-introduction to the wild (Tables 16.7 and 16.8). Thus well-documented species most vulnerable to

Figure 16.4 Time series of animal extinctions on islands and continents: selected taxa



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Figure 16.5 Time series of animal extinctions on islands and continents: all taxa



extinction during the past 30 years have often not become so, as a result of direct manipulative intervention. As noted above, it seems probable that significant numbers of undocumented continental species will have become extinct during this time.

CURRENT AND FUTURE EXTINCTION RATES

Habitat destruction, modification, and fragmentation are widely recognised as the most serious current threats to biological diversity, and the primary cause of recent extinctions. Estimates for present and projected global extinction rates have not been based on observed or recorded species extinctions, but rather on extrapolations from estimates of habitat loss coupled with assumptions derived from biogeography, relating numbers of species to area of habitat. A range of estimates are given in Table 16.3

In practice, most predictions of global extinction rates have been based on estimates of species richness in tropical forests, combined with estimates of actual and projected deforestation rates. Equating global species extinction with tropical forest species extinction has been justified by the recognition that the vast majority of terrestrial species occur in tropical moist forests.

The extrapolations from estimates of habitat loss are coupled with biogeographic assumptions using the species-area (Arrhenius) relation ($\log S = c + z \log A$) where S = number of species, A = area and c and z are constants (see Chapter 5). Values for z used are between 0.15 and 0.40.

The most widely quoted generalisation is that a ten-fold reduction in area (i.e. loss of 90% of habitat) results in the loss of half the species present (30% with $z = 0.15$; 60% with $z = 0.40$).

Recent estimates based on these assumptions include those of Ehrlich and Wilson (1991) and Reid and Miller (1989). The former, on the basis of a 1.8% loss of rain forest per year, and using 'conservative' estimates from biogeographic theory (i.e. low z values), estimate a loss of 2-3% of rain forest species per decade. Reid and Miller, using z values of 0.15-0.40 and the assumption that forest loss is 1-2 times that projected by FAO for the period 1980-85, derive a similar figure of 2-5% loss per decade. This translates into a loss of some 5-15% by the year 2020, assuming rates of forest loss continue to increase.

Reid (1992) has refined the analysis somewhat, applying figures for forest area and rates of loss separately to Latin America, Africa and Asia, and accounting for observed differences in species diversity between the three regions. Using z values of 0.15-0.35 he concludes that global loss of closed-forest species will be of the order of 1-5% per decade, or 2-8% in total between 1990 and 2015. Reid stresses (and this applies to other estimates of species loss) that this is the number of species 'committed' to eventual extinction as a result of forest loss, not the number which will actually become extinct during that time - in many cases, there will be a delay between reduction in area of habitat and the extinction of species dependent on that habitat, especially for longer-living species.

Table 16.3 Estimated rates of extinction

ESTIMATE	% GLOBAL LOSS PER DECADE	METHOD OF ESTIMATION	REFERENCE
One million species between 1975 and 2000	4	Extrapolation of past exponentially increasing trend	Myers (1979)
15-20% of species between 1980 and 2000	8-11	Estimated species-area curve; forest loss based on Global 2000 projections	Lovejoy (1980)
12% of plant species in neotropics. 15% of bird species in Amazon basin	-	Species-area curve ($z=0.25$)	Simberloff (1986)
2000 plant species per year in tropics and subtropics	8	Loss of half the species in area likely to be deforested by 2015	Raven (1987)
25% of species between 1985 and 2015	9	As above	Raven (1988a,b)
At least 7% of plant species	7	Half of species lost over next decade in 10 'hot spots' covering 3.5% of forest area	Myers (1988)
0.2-0.3% per year	2-3	Half of rain forest species assumed lost in tropical rain forests to be local endemics and becoming extinct with forest loss	Wilson (1988, 1989)
5-15% forest species by 2020	2-5	Species-area curve ($0.15 < z < 0.35$); forest loss assumed twice rate projected by FAO for 1980-85	Reid and Miller (1989)
2-8% loss between 1990 and 2015	1-5	Species-area curve ($0.15 < z < 0.35$); range includes current rate of forest loss and 50% increase	Reid (1992)

Source: Reid, W.V. 1992. How many species will there be? In: Whitmore, T.C. and Sayer, J.A. (Eds), *Tropical Deforestation and Species Extinction*, Chapman Hall, London, UK.

Notes: See original source for additional notes referring to this table and reference citations.

Estimates such as these are often combined with estimates of species numbers in tropical rain forests to provide figures for numbers of species disappearing daily, yearly or each decade. Figures of 100,000 species lost per year (based on estimates of 20 million tropical forest species) are frequently quoted. The vast majority of the hypothesised extinctions would occur among undescribed arthropods because these comprise the majority of the total number of species estimated to occur in tropical forest.

Earlier estimates, some based on similar biogeographic assumptions and others using different models, gave even higher projected rates of extinction, with figures of 20-50% species loss by the end of the century (Myers, 1979; Ehrlich and Ehrlich, 1981). In the light of the more recent estimates based on increased sophistication of the model, these earlier predictions now look exaggerated.

Problems with the model

Both the theoretical assumptions and the figures used in deriving estimates from the species-area model are open to question.

The principal assumption underlying the model is that species richness and habitat destruction within tropical

forests are distributed evenly. This is not the case, as richness is known to vary considerably between different areas of tropical moist forest at all scales of comparison (see Chapter 4). Many ecologists and taxonomists would agree that, given the inadequate data available on the poorly-known groups which make up most of the world's total complement of species, no realistic assessment can be made of the extent to which reduction of an area of forest habitat will affect the species present.

Areas also differ greatly in the number of species confined to them (i.e. endemics). Self-evidently, the complete destruction of even a small area with a large number of endemics will contribute more to global extinction than the destruction of the same-sized area with few or no local endemics, even if the latter is richer in species. Thus, if habitat destruction preferentially takes place in areas with large numbers of endemics it will lead to extinction rates higher than those estimated from mean species-area relationships, while if it is concentrated in areas with few endemics, the reverse will be the case.

Figures for rates of habitat destruction are also open to question (see Chapter 20). Calculations tend to take figures for forest conversion as equivalent to forest loss, that is complete destruction of forest and replacement by habitats

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in which none of the original biota can survive. In reality, forest conversion covers a range of conditions, from selective logging which may have relatively little impact on species composition, through small-scale patch-work clearing for agriculture, to clear-felling of extensive areas. Forest conversion thus covers a range of degrees of degradation, with only the most extreme resulting in complete elimination of all species from a particular area. This will tend therefore to reduce the estimates for extinction rates. In addition, projections of extinction rates are based on an assumption that deforestation rates will remain constant. This is evidently not the case. It is widely agreed that rates of forest conversion are increasing, and will continue to increase until easily accessible areas which are not legally protected have been cleared, following which they will decrease.

Furthermore, the estimate from a straightforward global species-area curve does not take into account the presumed 'residual' extinctions which will occur through remaining forest becoming fragmented: on the basis of island biogeographic theory it is argued that these fragments will suffer elevated rates of extinction through stochastic processes. Already many species may be committed to extinction in that without direct human intervention, their residual numbers are non-viable. The list of threatened species in Table 17.1 show 140 species of mammals as endangered and likely to become extinct in the near future unless the threat to their survival is alleviated: this is more than twice the total number of mammals that has gone extinct over the last four hundred years. Instead of concentrating on extinctions, it is important to monitor the status and threats to a wide array of species if global trends of species diversity are to be assessed.

Finally, estimates of extinction rates do not - and cannot - take into account the impact of unpredictable large-scale changes in environmental conditions, such as global climate change, which is likely to have a profound influence upon species survival.

Conclusion

There are many unsatisfactory assumptions underlying current estimates of global extinction rates, and the resulting numerical values are fraught with imprecision. Alternative models, possibly based on a greater understanding of the ecological or life history traits correlated to extinction proneness, would be highly instructive in either confirming current estimates or refining them by avoiding some of the major short-comings in the species - area method. However in the absence of such alternatives, conclusions from the different studies using the current model must be examined, even if the methodology is known to be flawed. In large measure, these agree about the accelerating rates of species extinctions arising from the continued loss of tropical forests. The most recent refinement of the estimates (Reid, 1992) predicts that at current rates of deforestation, we will commit some 2-8% of the planet's species to extinction in the next 25 years.

However, what is equally clear is that quantifying the precise rate of extinction is of no greater relevance to conservation practice than is determining a precise figure

for the number of species on earth. Policymakers and the public may like to assess the magnitude of the extinction crisis, and thus the priority to be given to the issue, on the basis of an absolute rate, but investment of time and effort in refining such predictions contributes little to tackling the root causes of the problem. Indeed, obsession with an absolute extinction rate may give an unrealistically optimistic impression in that no allowance is made for the genetic impoverishment of the multitude of species brought to the verge of extinction through the progressive loss of discrete sub-populations.

Rather than focus on refining extinction rates, we need to develop the capability to identify areas or localities of high species endemism and diversity (see Chapter 15), and ensure that these sites are placed under a system of conservation management that maintains their ecological integrity before they are perturbed by logging, mining or forest clearance. Such proactive conservation practice could stem the tide of the accelerating species extinction crisis.

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Based on text prepared by Martin Jenkins with additions by WCMC staff

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Table 16.4 Animal species extinct since circa 1600

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED CAUSE	POSSIBLE CAUSE
CORALS ETC. (Cnidaria)				
Order MILLEPORINA				
Family Milleporidae				
<i>Millepora sp.</i>		Panama	1983	
MOLLUSCS				
Order ARCHAEOGASTROPODA				
Family Acmaeidae				
<i>Lottia alveus</i>	Eelgrass Limpet	USA		B
Order MESOGASTROPODA				
Family Hydrobiidae				
<i>Bythiospeum pfeifferi</i>		Austria		
<i>Clappia umbilicata</i>	Umbilicate Pebblesnail	USA		
<i>Ohrdoehauffenia crinica</i>		Yugoslavia	1980s	
Family Pleuroceridae				
<i>Elimia clausa</i>	Closed Elimia	USA		B
<i>Elimia fusiformis</i>	Fusiform Elimia	USA		B
<i>Elimia hartmanniana</i>	High-spired Elimia	USA		B
<i>Elimia impressa</i>	Constricted Elimia	USA		B
<i>Elimia jonesi</i>	Hearty Elimia	USA		B
<i>Elimia laeta</i>	Ribbed Elimia	USA		B
<i>Elimia pilosbyi</i>	Rough-lined Elimia	USA		B
<i>Elimia pupaeformis</i>	Pupa Elimia	USA		B
<i>Elimia pygmaea</i>	Pygmy Elimia	USA		B
<i>Elimia varians</i>	Puzzle Elimia	USA		B
<i>Gyrotoma incisa</i>	Excised Slitshell	USA	1924	
<i>Gyrotoma lewisi</i>	Striate Slitshell	USA	1924	
<i>Gyrotoma pagoda</i>	Pagoda Slitshell	USA	1924	
<i>Gyrotoma pumila</i>	Ribbed Slitshell	USA	1924	
<i>Gyrotoma pyramidata</i>	Pyramid Slitshell	USA	1924	
<i>Gyrotoma walkeri</i>	Round Slitshell	USA	1924	
<i>Leptoxis clypeata</i>	Agate Rocksnail	USA		
<i>Leptoxis formanii</i>	Interrupted Rocksnail	USA		
<i>Leptoxis ligata</i>	Rotund Rocksnail	USA		
<i>Leptoxis lirata</i>	Lirate Rocksnail	USA		
<i>Leptoxis occultata</i>	Bigmouth Rocksnail	USA		
<i>Leptoxis showalteri</i>	Coosa Rocksnail	USA		
<i>Leptoxis vittata</i>	Striped Rocksnail	USA		
Family Pomatiidae				
<i>Tropidophora carinata</i>		Mauritius	1881	B
Order STYLOMMAТОPHORA				
Family Endodontidae				
<i>Discus guerinianus</i>		Madeira (Portugal)	1870s	
<i>Kondoconcha othnius</i>		Rapa (F. Polynesia)	1934	
<i>Liberia subcavernula</i>		Raratonga (Cook Is)	1880s	
<i>Liberia tumuloides</i>		Raratonga (Cook Is)	1880s	
<i>Mautodonta acuticosta</i>		Raiatea (F. Polynesia)	1880s	
<i>Mautodonta boraborensis</i>		Borabora (F. Polynesia)	1880s	
<i>Mautodonta ceuthma</i>		Raiavae (F. Polynesia)	1880s	
<i>Mautodonta consimilis</i>		Raiatea (F. Polynesia)	1880s	
<i>Mautodonta consobrina</i>		Huahine (F. Polynesia)	1880s	
<i>Mautodonta maupiensis</i>		Maupiti (F. Polynesia)	1880s	
<i>Mautodonta parvidens</i>		Society Is (F. Polynesia)	1880s	
<i>Mautodonta punctiperforata</i>		Moorea (F. Polynesia)	1880s	
<i>Mautodonta saintjohni</i>		Borabora (F. Polynesia)	1880s	
<i>Mautodonta subtilis</i>		Huahine (F. Polynesia)	1880s	
<i>Mautodonta unilamellata</i>		Raratonga (Cook Is)	1880s	
<i>Mautodonta zebra</i>		Raratonga (Cook Is)	1880s	
<i>Opanara altiapica</i>		Rapa (F. Polynesia)	1934	
<i>Opanara areaensis</i>		Rapa (F. Polynesia)	1934	
<i>Opanara bitridentata</i>		Rapa (F. Polynesia)	1934	
<i>Opanara caliculata</i>		Rapa (F. Polynesia)	1934	
<i>Opanara depasoapicata</i>		Rapa (F. Polynesia)	1934	
<i>Opanara duplicitentata</i>		Rapa (F. Polynesia)	1934	
<i>Opanara fosbergi</i>		Rapa (F. Polynesia)	1934	
<i>Opanara megomphala</i>		Rapa (F. Polynesia)	1934	
<i>Opanara perahuensis</i>		Rapa (F. Polynesia)	1934	
<i>Orangia cooki</i>		Rapa (F. Polynesia)	1934	
<i>Orangia maituitensis</i>		Rapa (F. Polynesia)	1934	
<i>Orangia sporadica</i>		Rapa (F. Polynesia)	1934	
* <i>Piliula cycloria</i>		Mauritius		
. <i>Rhysococoncha atanuiensis</i>		Rapa (F. Polynesia)	1934	
. <i>Rhysococoncha variumbilicata</i>		Rapa (F. Polynesia)	1934	
. <i>Ruatara koarana</i>		Rapa (F. Polynesia)	1934	
. <i>Ruatara opatica</i>		Rapa (F. Polynesia)	1934	
<i>Taipidion anceyan</i>		Hiva Oa (F. Polynesia)	1880s	
<i>Taipidion marquesana</i>		Nuku Hiva (F. Polynesia)	1880s	
<i>Taipidion octolamellata</i>		Hiva Oa (F. Polynesia)	1880s	
<i>Thaumatodon multilamellatus</i>		Raratonga (Cook Is)	1880s	
Family Bulimulidae				
<i>Amphibulima patula</i>		Guadeloupe		B
<i>Bulimulus duncanus</i>		Galapagos (Ecuador)	late 1800s	H
<i>Leuchocharis loyalityensis</i>		New Caledonia	1900s	B
<i>Leuchocharis porphyrocheila</i>		New Caledonia	1900s	B

Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
MOLLUSCS (continued)				
Family Charopidae				
<i>Heleonoconcha leptalea</i>		St Helena	1870s	
<i>Heleonoconcha minutissima</i>		St Helena	1870s	
<i>Heleonoconcha polyodon</i>		St Helena	1870s	
<i>Heleonoconcha pseustes</i>		St Helena	1870s	
<i>Heleonoconcha sexdentata</i>		St Helena	1870s	
<i>Helenodiscus bilamellata</i>		St Helena	1870s	
<i>Helenodiscus vernoni</i>		St Helena	1870s	
<i>Pseudohelenoconcha dianae</i>		St Helena	1870s	
<i>Pseudohelenoconcha laetissima</i>		St Helena	1870s	
<i>Pseudohelenoconcha persoluta</i>		St Helena	1870s	
<i>Pseudohelenoconcha spurca</i>		St Helena	1870s	
<i>Sinployea canalis</i>		Raratonga (Cook Is)	1872	
<i>Sinployea decorticata</i>		Raratonga (Cook Is)	1872	
<i>Sinployea harveyensis</i>		Raratonga (Cook Is)	1872	
<i>Sinployea otareae</i>		Raratonga (Cook Is)	1872	
<i>Sinployea planospira</i>		Raratonga (Cook Is)	1872	
<i>Sinployea proxima</i>		Raratonga (Cook Is)	1872	
<i>Sinployea rufis</i>		Raratonga (Cook Is)	1872	
<i>Sinployea tenuicostata</i>		Raratonga (Cook Is)	1872	
<i>Sinployea youngi</i>		Raratonga (Cook Is)	1872	
Family Achatinellidae				
<i>Achatinella abbreviata</i>		Hawaii (USA)	1963	A,C,D
<i>Achatinella buddii</i>		Hawaii (USA)	early 1900s	A,C,D
<i>Achatinella caesia</i>		Hawaii (USA)	early 1900s	A,C,D
<i>Achatinella casta</i>		Hawaii (USA)		A,C,D
<i>Achatinella decora</i>		Hawaii (USA)		A,C,D
<i>Achatinella elegans</i>		Hawaii (USA)	early 1900s	A,C,D
<i>Achatinella judii</i>		Hawaii (USA)	1952	A,C,D
<i>Achatinella juncea</i>		Hawaii (USA)	1958	A,C,D
<i>Achatinella lehuensis</i>		Hawaii (USA)		A,C,D
<i>Achatinella papyracea</i>		Hawaii (USA)	1922	A,C,D
<i>Achatinella rosea</i>		Hawaii (USA)	1945	A,C,D
<i>Achatinella spaldingi</i>		Hawaii (USA)	1949	A,C,D
<i>Achatinella stewarti</i>		Hawaii (USA)	1938	A,C,D
<i>Achatinella thaanumi</i>		Hawaii (USA)	1961	A,C,D
<i>Achatinella valida</i>		Hawaii (USA)	1900s	A,C,D
<i>Achatinella vittata</i>		Hawaii (USA)	1951	A,C,D
x <i>Elasmias jauffreti</i>		Rodrigues (Mauritius)	1953	A,C,D
x <i>Elasmias</i> sp.		Mauritius		
<i>Partulina crassa</i>		Hawaii (USA)	1914	C?
<i>Partulina montagui</i>		Hawaii (USA)	1913	C?
Family Partulidae				
<i>Partula exigua</i>	Moorean Viviparous Tree Snail	Moorea (F. Polynesia)	1977	C?
<i>Partula filosa</i>	Tahiti Viviparous Tree Snail	Tahiti (F. Polynesia)		
<i>Partula producta</i>	Tahiti Viviparous Tree Snail	Tahiti (F. Polynesia)		
<i>Partula salifara</i>		Guam		
<i>Samoana abbreviata</i>		American Samoa	1940	B
Family Amastridae				
<i>Carelia anceophila</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia bicolor</i>		Hawaii (USA)	1970	B,C,D
<i>Carelia cumingiana</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia glossema</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia kalalauensis</i>		Hawaii (USA)	1945/47	B,C,D
<i>Carelia knudseni</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia olivacea</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia paradoxa</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia perisceles</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia tenebrosa</i>		Hawaii (USA)	1930	B,C,D
<i>Carelia turricula</i>		Hawaii (USA)	1930	B,C,D
Family Vertiginidae				
<i>Campolaemus peregrinus</i>		St Helena	1870s	
<i>Nesopupa turtoni</i>		St Helena	1870s	
Family Pupillidae				
x <i>Gibbulinopsis</i> sp.		Rodrigues (Mauritius)		
<i>Leiostyla abbreviata</i>		Madeira (Portugal)	1870s	
<i>Leiostyla cassida</i>		Madeira (Portugal)	1870s	
<i>Leiostyla concinna</i>		Madeira (Portugal)	1870s	
<i>Leiostyla gibba</i>		Madeira (Portugal)	1870s	
<i>Leiostyla laevigata</i>		Madeira (Portugal)	1870s	
<i>Leiostyla lamellosa</i>		Madeira (Portugal)	1870s	
<i>Leiostyla simulator</i>		Madeira (Portugal)	1870s	
<i>Pupa obliquicostata</i>		St Helena	1870s	
Family Helixarionidae				
<i>Colparion madgei</i>		Rodrigues (Mauritius)	1938	B
<i>Ctenoglypta newtoni</i>		Mauritius	1871	B
x <i>Ctenophila planorbina</i>		Mauritius		
<i>Diastole matafaoi</i>		American Samoa	1940	?D
x <i>Erepta thiriouxi</i>		Mauritius		
x <i>Erepta</i> sp.		Mauritius		
<i>Pachystyla ruforufata</i>		Mauritius	1869	B
x <i>Plegma bewsheri</i>		Rodrigues (Mauritius)		
x <i>Plegma duponti</i>		Mauritius		
x <i>Plegma</i> sp.		Mauritius		
Family Ferussaciidae				
<i>Cecilioides eulima</i>		Madeira (Portugal)	1870s	
Family Subulinidae				
<i>Chilonopsis blafeldi</i>		St Helena	1870s	
<i>Chilonopsis exulatus</i>		St Helena	1870s	
<i>Chilonopsis helena</i>		St Helena	1870s	

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Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
MOLLUSCS (continued)				
<i>Chilonopsis melanoides</i>		St Helena	1870s	
<i>Chilonopsis nonpareil</i>		St Helena	1870s	
<i>Chilonopsis subuplicatus</i>		St Helena	1870s	
<i>Chilonopsis subtruncatus</i>		St Helena	1870s	
<i>Chilonopsis turtoni</i>		St Helena	1870s	
Family Helicidae				
<i>Discula lyellana</i>		Madeira (Portugal)	1870s	
<i>Discula tetrica</i>		Madeira (Portugal)	1870s	
<i>Geomitra delphinuloides</i>		Madeira (Portugal)	1870s	
<i>Lemniscia galatea</i>		Madeira (Portugal)	1870s	
<i>Pseudocampylaea lowei</i>		Madeira (Portugal)	late 19th C	
Family Streptaxidae				
<i>Edentulina thomasetti</i>		Seychelles	1908	
<i>Gibbus lyonetianus</i>		Mauritius	1905	B
<i>Gonidomus newtoni</i>		Mauritius	1867	B
x <i>Gonospira cireneensis</i>		Mauritius		
x <i>Gonospira heliodes</i>		Mauritius		
x <i>Gonospira majusculus</i>		Mauritius		
<i>Imperturbata violescens?</i>		Seychelles		
Family Assimineidae				
x <i>Omphalotropis plicosa</i>		Mauritius	1878	B
x <i>Omphalotropis caldwelli</i>		Mauritius		
x <i>Omphalotropis dupontiana</i>		Mauritius		
x <i>Omphalotropis maxima</i>		Mauritius		
x <i>Omphalotropis multilirata</i>		Mauritius		
x <i>Omphalotropis sp.</i>		Mauritius		
Family Pomatiidae				
x <i>Tropidophora bewsheri</i>		Rodrigues (Mauritius)		
x <i>Tropidophora bipartita</i>		Rodrigues (Mauritius)		
x <i>Tropidophora deflorata</i>		Réunion		
x <i>Tropidophora lienardi</i>		Mauritius		
x <i>Tropidophora mauritiana</i>		Mauritius		
Order UNIONOIDA				
Family Unionidae				
<i>Alasmidonta mccordi</i>	Coosa Elktoe	USA		
<i>Alasmidonta wrightiana</i>	Ochlocknee Arc-mussel	USA		
<i>Epioblasma arcaeformis</i>	Sugarspoon	USA	1940s	B
<i>Epioblasma biemarginata</i>	Angled Riffleshell	USA	1960s	B
<i>Epioblasma flexuosa</i>	Leafshell	USA	1940s	B
<i>Epioblasma haynsiana</i>	Acornshell	USA		
<i>Epioblasma lenior</i>	Narrow Catspaw	USA	1965	B
<i>Epioblasma lewisi</i>	Forkshell	USA	1964	B
<i>Epioblasma personata</i>	Round Combshell	USA	1930	B
<i>Epioblasma propinqua</i>	Tennessee Riffleshell	USA	1930	B
<i>Epioblasma sampsoni</i>	Wabash Riffleshell	USA		
<i>Epioblasma stewartsoni</i>	Cumberland Leafshell	USA	1950s/60s	B
<i>Medionidus mcglaumeriae</i>	Tombigbee Moccasinshell	USA	1930	B
Order AMPHIPODA				
Family Crangonyctidae				
<i>Stygobromus hayi</i>	Hay's Spring Scud	USA	1957	
<i>Stygobromus lucifugus</i>	Rubious Cave Amphipod	USA		
Order DECAPODA				
Family Astacidae				
<i>Pacifastacus nigrescens</i>	Sooty Crayfish	USA	1860s	
Family Atyidae				
<i>Syncaris pasadenae</i>	Pasadena Freshwater Shrimp	USA	1933	
Order EPHEMEROPTERA				
Family Siphlonuridae				
<i>Acanthometropus pecatoniae</i>	Pecatonica River Mayfly	USA	1927	
Family Ephemeridae				
<i>Pantagenia robusta</i>	Robust Burrowing Mayfly	USA		
Order ORTHOPTERA				
Family Tettigoniidae				
<i>Neduba extincta</i>	Antioch Dunes Shieldback Katydid	USA	1937	
Order PHASMATOPTERA				
Family Phasmatidae				
<i>Dryococelus australis</i>	Lord Howe Island Stick-insect	Lord Howe I (Australia)	1969	
Order DERMAPTERA				
Family Labiduridae				
* <i>Labidura herculeana</i>	St Helena Earwig	St Helena	1967	
Order PLECOPTERA				
Family Chloroperlidae				
<i>Alioperla roberti</i>	Robert's Stonefly	USA		

Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
INSECTS (continued)				
Order HOMOPTERA				
Family Pseudococcidae				
<i>Clavigoccus erinaceus</i>		Hawaii (USA)		
<i>Phyllocoptes oahuensis</i>		Hawaii (USA)		
Order COLEOPTERA				
Family Cerambycidae				
<i>Xylotrechus costatus</i>	Pitt Island Longhorn Borer	Chatham I (NZ)	1930s	B,C
Family Curculionidae				
<i>Dryophthorus distinguendus</i>		Hawaii (USA)		
<i>Dryotribus mimeticus</i>		Hawaii (USA)		
<i>Hecatomphus tuberculatus</i>		New Zealand		
<i>Macrancylus linearis</i>		Hawaii (USA)		
<i>Oedemasius laysanensis</i>		Hawaii (USA)		
<i>Pentarthrum blackburnii</i>		Hawaii (USA)		
<i>Rhyncogonus bryani</i>		Hawaii (USA)		
Family Carabidae				
* <i>Apolithorax burchelli</i>		St Helena	1967?	
* <i>Mecodema punctellum</i>		Stephens I (NZ)		B,G
Order DIPTERA				
Family Tabanidae				
<i>Stomemyia volutina</i>	Volutine Stoneyian Tabanid Fly	USA		
Family Dolichopodidae				
<i>Campsicnemus mirabilis</i>		Hawaii (USA)		
Family Drosophilidae				
<i>Drosophila lanaiensis</i>		Hawaii (USA)		
Order TRICHOPTERA				
Family Rhyacophilidae				
<i>Rhyacophila amabilis</i>	Castle Lake Caddis-fly	USA		
Family Hydropsychidae				
<i>Hydropsyche tobiasi</i>	Tobias' Caddis-fly	Germany	1920s	
Family Leptoceridae				
<i>Triænodes phalaris</i>	Athens Caddis-fly	USA		
<i>Triænodes tridonata</i>	Three-tooth Caddis-fly	USA		
Order LEPIDOPTERA				
Family Zygaenidae				
<i>Leuvana iridescentia</i>	Leuvana Moth	Fiji	1929	E
Family Lycaenidae				
<i>Glaucopsyche xerxes</i>	Xerces Blue	USA	early 1940s	
Family Libytheidae				
<i>Libythea cinnaras</i>		Mauritius	1865	
Family Nymphalidae				
<i>Euthalia malapana</i>		Taiwan		
Family Pyralidae				
<i>Genophantis leahi</i>		Hawaii (USA)	early 1900s	
<i>Hedylepta asaphombra</i>		Hawaii (USA)	1970s	
<i>Hedylepta coninutalis</i>		Hawaii (USA)	1958	
<i>Hedylepta epicentra</i>		Hawaii (USA)	early 1900s	
+ <i>Hedylepta euryprora</i>		Hawaii (USA)		E
+ <i>Hedylepta fullawayi</i>		Hawaii (USA)		E
+ <i>Hedylepta laysanensis</i>		Hawaii (USA)		E
+ <i>Hedylepta meyricki</i>		Hawaii (USA)		E
+ <i>Hedylepta musicola</i>		Hawaii (USA)		E
+ <i>Hedylepta telegrapha</i>		Hawaii (USA)		
<i>Oeobia</i> sp.		Hawaii (USA)	1911	
Family Geometridae				
<i>Scotorrhyncha nesiotes</i>		Hawaii (USA)	early 1900s	
<i>Scotorrhyncha megalophylla</i>		Hawaii (USA)	early 1900s	
<i>Scotorrhyncha paratactis</i>		Hawaii (USA)	early 1900s	
<i>Tritocleis microphylla</i>		Hawaii (USA)	1890s	
Family Sphingidae				
<i>Mandura blackburni</i>		Hawaii (USA)	1960s	
Family Noctuidae				
<i>Agrotis crinigera</i>	Poco Noctuid Moth	Hawaii (USA)	1926	E
<i>Agrotis fasciata</i>	Midway Noctuid Moth	Hawaii (USA)	1923	
<i>Agrotis kerri</i>		Hawaii (USA)	1911	
<i>Agrotis laysanensis</i>		Hawaii (USA)		
<i>Agrotis photophila</i>		Hawaii (USA)	pre-1900	
<i>Agrotis procellaris</i>		Hawaii (USA)	post-1927	
<i>Helicoverpa confusa</i>		Hawaii (USA)	pre-1911	
<i>Helicoverpa minuta</i>		Hawaii (USA)	1911	
<i>Hypena laysanensis</i>	Minute Noctuid Moth	Hawaii (USA)		
+ <i>Hypena newelli</i>	Laysan Dropseed Noctuid Moth	Hawaii (USA)		
+ <i>Hypena plagiota</i>		Hawaii (USA)		
+ <i>Hypena senicula</i>		Hawaii (USA)		
<i>Peridroma porphyrea</i>		Hawaii (USA)		
Order HYMENOPTERA				
Family Colletidae				
<i>Nesoprosopis angustula</i>	Lanai Yellow-faced Bee	Hawaii (USA)		
<i>Nesoprosopis blackburni</i>	Blackburn's Yellow-faced Bee	Hawaii (USA)		
<i>Nesoprosopis connectens</i>	Connected Yellow-faced Bee	Hawaii (USA)		

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Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
FISHES				
Order PETROMYZONTIFORMES				
Family Petromyzontidae <i>Lampetra minima</i>	Miller Lake Lamprey	USA	1953	E
Order CYPRINIFORMES				
Family Cyprinidae <i>Evarra bustamantei</i> <i>Evarra eigenmanni</i> <i>Evarra tlahuacensis</i> <i>Gila crassicauda</i> <i>Lepidomeda ativelis</i> <i>Notropis amecaes</i> <i>Notropis aulidion</i> <i>Notropis orca</i> <i>Pogonichthys cinctoides</i> <i>Rhinichthys deaconi</i> <i>Stypondon signifer</i>	Thicktail Chub Pahranagat Spinedace Ameba Shiner Durango Shiner Phantom Shiner Clear Lake Splittail Las Vegas Dace Stumptooth Minnow	Mexico Mexico Mexico USA USA Mexico Mexico Mexico Mexico Mexico Mexico	1970 1970 1970 1957 1940 1970 1965 1975 1970 1955 1930	B B B B,C/D C/D C/D C/D B,C/D B,C/D
Family Catostomidae <i>Chasmistes murieci</i> <i>Lagochila lacera</i>	Snake River Sucker Harelip Sucker	USA USA	1928 1910	B G
Order SALMONIFORMES				
Family Retropinnidae * <i>Prototroctes oxyrhynchus</i>	New Zealand Grayling	New Zealand	1920s	B,D,H
Family Salmonidae <i>Coregonus alpenae</i> <i>Coregonus johnnae</i> <i>Salvelinus agassizi</i>	Longjaw Cisco Deepwater Cisco Silver Trout	USA, Canada USA, Canada USA	1978 1955 1930	A,C A,C/D A,C/D
Order CYPRINODONTIFORMES				
Family Fundulidae <i>Fundulus albolineatus</i>	Whiteline Topminnow	USA	1900	B,C/D
Family Poeciliidae <i>Gambusia amistadensis</i> * <i>Gambusia georgei</i> * <i>Priapella bonita</i>	Amistad Gambusia San Marcos Gambusia Guayacon Ojiazul	USA USA Mexico	1973 1983	B B,C/D
Family Goodeidae <i>Characodon garmani</i> <i>Empetrichthys merriami</i>	Parras Characodon Ash Meadows Killifish	Mexico USA	1900 1953	?B B,C/D
Family Cyprinodontidae <i>Cyprinodon latifasciatus</i> <i>Cyprinodon sp.</i> <i>Cyprinodon sp.</i> <i>Cyprinodon sp.</i>	Perrito de Parras Monkey Spring Pupfish	Mexico USA Mexico Mexico	1930 1971	B B,C/D
Order SCORPAENIFORMES				
Family Cottidae <i>Cottus echinatus</i>	Utah Lake Sculpin	USA	1928	B,C/D
AMPHIBIANS				
Order ANURA				
Family Discoglossidae <i>Discoglossus nigroventer</i> <i>Rana fisheri</i>	Israel Painted Frog Relict Leopard Frog	Israel USA	1940 1960	B B
REPTILES				
Order TESTUDINES				
Family Testudinidae <i>Cylindraspis borbonica</i> <i>Cylindraspis indica</i> <i>Cylindraspis inepta</i> <i>Cylindraspis petastes</i> <i>Cylindraspis triserrata</i> <i>Cylindraspis vosmaeri</i>		Réunion Réunion Mauritius Rodrigues (Mauritius) Mauritius Rodrigues (Mauritius)	1800 1800 early 18th C 1800 early 18th C 1800	A,C/D A,B,C/D A,C/D A,C/D
Order SAURIA				
Family Gekkonidae <i>Hoplodactylus delcourti</i> <i>Phelsuma edwardnewtoni</i> <i>Phelsuma gigas</i>	Newton's Day Gecko Giant Day Gecko	New Zealand (?) Rodrigues (Mauritius) Rodrigues (Mauritius)	mid 19th C? 1917 end 19th C	C C C?
Family Iguanidae <i>Leiocephalus eremitus</i> <i>Leiocephalus herminieri</i>		Navassa I (USA) Martinique	1900 1830s	C —
Family Teiidae <i>Ameiva cineracea</i> * <i>Ameiva major</i>	Martinique Giant Ameiva	Guadeloupe Martinique	early 20th C	— C?
Family Anguidae <i>Celestus occiduus</i>	Jamaican Giant Galliwasp	Jamaica	1840	C?
Family Scincidae # <i>Leiolopisma mauritianum</i> <i>Macroscincus coctei</i> * <i>Tiliqua adelaidensis</i>	Cape Verde Giant Skink Adelaide Pigmy Bluetongue	Mauritius Cape Verde Australia	1600 early 20th C 1959	C A? B,C

Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
REPTILES (continued)				
Order SERPENTES				
Family Boidae				
* <i>Bolyeria multocarinata</i>		Round I (Mauritius)	1975	
Family Typhlopidae				
* <i>Typhlops cariei</i>		Mauritius	17th C	C
Family Colubridae				
* <i>Alsophis ater</i>	Jamaican Tree Snake	Jamaica	1950	A,C
* <i>Alsophis sanctacrucis</i>	St Croix Racer	Virgin Is (US)	20th C	A,C
* <i>Liothpis cursor</i>	Martinique Racer	Martinique	1963	C
* <i>Liothpis perfuscus</i>	Barbados Racer	Barbados	mid 20th C?	C
BIRDS				
Order STRUTHIONIFORMES				
Family Dromaiidae				
* <i>Dromaius diemenianus</i>	Kangaroo Island Emu	Kangaroo I (Australia)	1803	B
Family Aepyornithidae				
* <i>Aepyornis maximus</i>	Great Elephantbird	Madagascar	1650	A,B
Family Anomalopterygidae				
* <i>Dinornis torosus</i>	Brawny Great Moa	New Zealand	1670	A,B
* <i>Eurapteryx gravis</i>	Burly Lesser Moa	New Zealand	1640	A,B
* <i>Megalapteryx didinus</i>	South Island Tokoewa	New Zealand	1785	A,B
Order GALLIFORMES				
Family Phasianidae				
* <i>Coturnix novaezealandiae</i>	New Zealand Quail	New Zealand	1875	F
* <i>Ophrysia superciliosa</i>	Himalayan Mountain Quail	India	1868	A
Order ANSERIFORMES				
Family Anatidae				
* <i>Alopochen mauritanus</i>	Mauritian Shelduck	Mauritius	1698	—
* <i>Anas theodori</i>	Mauritian Duck	Mauritius, Réunion	1696	—
* <i>Campthorhynchus labradorius</i>	Labrador Duck	Canada, USA	1878	A,B
* <i>Cygnus sumnerensis</i>	Chatham Island Swan	Chatham I (NZ)	1590–1690	—
* <i>Mergus australis</i>	Auckland Island Merganser	New Zealand	1905	A,B,C
* <i>Rhodonessa caryophyllacea</i>	Pink-headed Duck	India, Nepal	1935	A
<i>Sheldgoose sp.</i>		Réunion	1674	—
Order CORACIFORMES				
Family Alcedinidae				
* <i>Halcyon miyakensis</i>	Ryukyu Kingfisher	Nansei-shoto (Japan)	1841	—
Order CUCULIFORMES				
Family Cuculidae				
* <i>Coua delalandei</i>	Snail-eating Coua	Madagascar	1930	A,B,C/D
Order PSITTACIFORMES				
Family Psittacidae				
* <i>Anodorhynchus glaucus</i>	Glaucus Macaw	Brazil, Uruguay	1955	
* <i>Ara tricolor</i>	Cuban Red Macaw	Cuba	1885	A,E
* <i>Charmosyna diadema</i>	New Caledonia Lorikeet	New Caledonia	1860	B
* <i>Conuropsis carolinensis</i>	Carolina Parakeet	USA	1914	E
* <i>Cyanoramphus ulietanus</i>	Raiatea Parakeet	Raiatea (F. Polynesia)	1773	—
* <i>Cyanoramphus zealandicus</i>	Black-fronted Parakeet	Tahiti (F. Polynesia)	1844	B
* <i>Lophopsittacus' bensonii</i>	Mauritius Grey Parrot	Mauritius	1765	C/D
* <i>Lophopsittacus mauritanus</i>	Mauritius Parrot	Mauritius	1675	A,C
* <i>Mascarinus mascarinus</i>	Mascarene Parrot	Réunion	1775 (1834 in captivity)	B
* <i>'Necropsittacus' rodericanus</i>	Rodrigues Parrot	Rodrigues (Mauritius)	1761	A,C/D
* <i>Nestor productus</i>	Norfolk Island Kaka	Philip I (Australia)	1851	A,E
* <i>Psittacula exsul</i>	Rodrigues Ring-necked Parakeet	Rodrigues (Mauritius)	1876	B
* <i>Psittacula wardi</i>	Seychelles Alexandrine Parrot	Seychelles	1870	A,B
Order TROCHILIFORMES				
Family Trochilidae				
* <i>Chlorostilbon bracei</i>	New Providence Hummingbird	Bahamas	1877	
Family Caprimulgidae				
* <i>Siphonorhis americanus</i>	Jamaica Least Pauraque	Jamaica	1859	C
Order STRIGIFORMES				
Family Strigidae				
* <i>Athene blewitti</i>	Forest Owl	India	1914	
* <i>'Athene' murivora</i>	Rodrigues Little Owl	Rodrigues (Mauritius)	1726	B
? <i>Seauzieri sp.</i>	Mauritian Owl	Mauritius		
* <i>Sceloglaux albifacies</i>	Laughing Owl	New Zealand	1914	B,C
* <i>'Scops' commersoni</i>	Mauritian Owl	Mauritius	1836	
Family Aegothelidae				
* <i>Aegotheloides savesi</i>	New Caledonia Owl-frogmouth	New Caledonia	1880	—
Order COLUMBIFORMES				
Family Raphidae				
* <i>'Ornithoptera' solitaria</i>	Réunion Solitaire	Réunion	1710–1715	A
* <i>Pezophaps solitarius</i>	Rodrigues Solitaire	Rodrigues (Mauritius)	1765	A
* <i>Raphus cucullatus</i>	Dodo	Mauritius	1665	A,C,D

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Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
BIRDS (continued)				
Family Columbidae				
<i>Alectroenas nitidissima</i>	Pigeon Hollandais	Mauritius	1835	A,C
' <i>Alectroenas</i> ' <i>rodericana</i>	Rodrigues Pigeon	Rodrigues (Mauritius)	1726	C/D
<i>Columba jouyi</i>	Ryukyu Wood Pigeon	Nansei-shoto (Japan)	1936	B
<i>Columba versicolor</i>	Bonin Wood Pigeon	Ogasawara-shoto (Japan)	1889	C
<i>Ectopistes migratorius</i>	Passenger Pigeon	USA	1914	A,B
* <i>Micrargous meeki</i>	Solomon Island Crowned-pigeon	Choiseul (Solomon Is)	1904	C
* <i>Ptilinopus mercieri</i>	Marquesas Fruit-dove	Marquesas Is (F. Polynesia)	1922	C/D
Order GRUIFORMES				
Family Rallidae				
<i>Aphanapteryx bonasia</i>	Red Rail	Mauritius	1700	A,C/D
<i>Aphanapteryx leguati</i>	Rodrigues Rail	Rodrigues (Mauritius)	1761	-
<i>Atlantis elpenor</i>	Ascension Flightless Crake	Ascension I (UK)	1656	G(A,C)
<i>Fulica newtoni</i>	Mascarene Coot	Mauritius, Réunion	1693	-
<i>Gallinula nesiotis</i>	Tristan Moorhen	Tristan da Cunha (UK)	1875-1900	C
<i>Gallinula pacifica</i>	Samoan Woodhen	Savaii (Western Samoa)	1908-1926	C
<i>Gallirallus pacificus</i>	Tahiti Rail	French Polynesia	1773-4	
<i>Nesoclopeus woodfordi</i>	Woodford's Rail	Bougainville (Papua New Guinea)	1936	-
<i>Porphyrio albus</i>	Lord Howe Purple Gallinule	Lord Howe I (Australia)	1834	A
<i>Porzana monasa</i>	Kosrae Crake	Federated States of Micronesia	1827	C
<i>Porzana palmeri</i>	Laysan Rail	Hawaii (USA)	1944	C,D
<i>Porzana sandwichensis</i>	Hawaiian Rail	Hawaii (USA)	1898	C
<i>Rallus dieffenbachii</i>	Chatham Island Banded Rail	Chatham I (NZ)	1840	B,C
<i>Rallus modestus</i>	Chatham Island Rail	Chatham I (NZ)	1900	D
<i>Rallus wakensis</i>	Wake Island Rail	Wake I (USA)	1945	A
* <i>Tricholimnas lafresnayanus</i>	New Caledonia Rail	New Caledonia	1904	-
Order CICONIIFORMES				
Family Scolopacidae				
<i>Prosobonia leucoptera</i>	Tahitian Sandpiper	Tahiti, Moorea (F. Polynesia)	1773	D
Family Charadriidae				
<i>Haematopus meadewaldoi</i>	Canarian Black Oystercatcher	Canary Is (Spain)	1913	G
<i>Vanellus macropterus</i>	Javanese Wattled Lapwing	Java (Indonesia)	1940	A,B
Family Laridae				
<i>Alca impennis</i>	Great Auk	Canada, Iceland, Faeroes UK, 'USSR', Greenland	1844	A
Family Falconidae				
<i>Falco sp.</i>				
<i>Polyborus lutosus</i>	Guadalupe Caracara	Réunion	1674	-
		Guadalupe (Mexico)	1900	A,D,E
Family Podicipedidae				
<i>Podiceps andinus</i>	Colombian Grebe	Colombia	1977	-
<i>Podilymbus gigas</i>	Attilan Grebe	Guatemala	1980-1986/7	A,D
<i>Tachybaptus rufolavatus</i>	Lake Alaotra Grebe	Madagascar		
Family Phalacrocoracidae				
<i>Phalacrocorax perspicillatus</i>	Spectacled Cormorant	Bering Straits ('USSR')	1852	A
Family Ardeidae				
<i>Ixobrychus novaezealandiae</i>	New Zealand Little Bittern	New Zealand	1900	-
<i>Nycticorax mauritianus</i>	Mauritius Night-heron	Mauritius	by 1700	-
<i>Nycticorax megacephalus</i>	Rodrigues Night-heron	Rodrigues (Mauritius)	1761	-
<i>Nycticorax sp.</i>		Réunion	by 1700	-
Family Threskiornithidae				
<i>Borbonibis latipes</i>	Reunion Flightless Ibis	Réunion	1773	-
Family Ciconiidae				
<i>Ciconia sp.</i>		Réunion	1674	-
Family Procellariidae				
* <i>Oceanodroma macrodactyla</i>	Guadalupe Storm-petrel	Guadalupe (Mexico)	1912-1922	C
<i>Pterodroma sp.</i>		Rodrigues (Mauritius)	1726	-
Order PASSERIFORMES				
Family Acanthizidae				
<i>Xenicus longipes</i>	Bush Wren	New Zealand	1972	B,C
<i>Xenicus lyalli</i>	Stephens Island Wren	Stephens I (NZ)	1874	C
Family Pycnonotidae				
<i>Hypsipetes sp.</i>		Rodrigues (Mauritius)	1600s?	-
Family Muscicapidae				
<i>Acrocephalus familiaris</i>	Laysan Millerbird	Hawaii (USA)	1912-1923	B,D
<i>Eutrichomyias rowleyi</i>	Caerulean Paradise-flycatch	Sangihe (Indonesia)	1978	B
<i>Myiagra freycineti</i>	Guam Broadbill	Guam	1983	
* <i>Turnagra capensis</i>	Pipio	New Zealand	1955	B,C
<i>Turdus rufidus</i>	Grand Cayman Thrush	Cayman Is	1938	B
<i>Zoothera terrestris</i>	Kittlitz's Thrush	Ogasawara-shoto (Japan)	1928	C
<i>Babbler sp.</i>		Rodrigues (Mauritius)	1600s?	-
Family Dicaeidae				
<i>Dicaeum quadricolor</i>	Four-coloured Flowerpecker	Cebu (Philippines)	1906	B
Family Zosteropidae				
<i>Zosterops stenurus</i>	Lord Howe White-eye	Lord Howe I (Australia)	1928	A,B,C/D
Family Meliphagidae				
<i>Chaetoptila angustipluma</i>	Kioea	Hawaii (USA)	1860	B
<i>Moho apicalis</i>	Oahu Oo	Hawaii (USA)	1837	A,B,C/D
* <i>Moho nobilis</i>	Hawaii Oo	Hawaii (USA)	1934	A,B,C/D

Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
BIRDS (continued)				
<i>Ciridops anna</i>	Ula-ai-hawane	Hawaii (USA)	1892	—
<i>Drepanis funerea</i>	Black Mamo	Hawaii (USA)	1907	—
<i>Drepanis pacifica</i>	Hawaii Mamo	Hawaii (USA)	1899	A,B
* <i>Hemignathus obscurus</i>	Akialoa	Hawaii (USA)	1960	
<i>Hemignathus sagittirostris</i>	Greater Amakihi	Hawaii (USA)	1900	B
* <i>Paroreomyza flammea</i>	Kakawihie or Molokai Creeper	Hawaii (USA)	1963	—
<i>Pitheciorstra kona</i>	Kona Grosbeak	Hawaii (USA)	1894	—
<i>Rhodacanthis flaviceps</i>	Lesser Koa-finch	Hawaii (USA)	1891	—
<i>Rhodacanthis palmeri</i>	Greater Koa-finch	Hawaii (USA)	1896	—
Family Icteridae				
<i>Quiscalus palustris</i>	Slender-billed Grackle	Mexico	1910	B
Family Ploceidae				
<i>Foudia sp.</i>	Reunion Fody	Réunion	1871	
Family Fringillidae				
<i>Chaunoproctus ferreirostris</i>	Bonin Grosbeak	Ogasawara-shoto (Japan)	1890	B,C/D
<i>Spizella townsendi</i>	Townsend's Finch	USA	1833	
Family Sturnidae				
<i>Aplonis corvina</i>	Kosrae Mountain Starling	Kosrae (Fed. States Micronesia)	1828	C
<i>Aplonis fusca</i>	Norfolk Island Starling	Norfolk I (Australia)	1925	—
<i>Aplonis mavornta</i>	Mysterious Starling	Cook Is	1825	C/D
* <i>Aplonis pelzelni</i>	Pohnpei Mountain Starling	Pohnpei (Fed. States Micronesia)	1956	B
<i>Fregilupus varius</i>	Réunion Starling	Réunion	1850–1860	B,C/D
<i>Necrospar rodericanus</i>	Rodrigues Starling	Rodrigues (Mauritius)	1726	—
Family Callaeidae				
<i>Heteralocha acutirostris</i>	Huia	New Zealand	1907	A,B,C/D
MAMMALS				
Order MARSUPIALIA				
Family Macropodidae				
* <i>Caloprymnus campestris</i>	Desert Rat-kangaroo	Australia	1935	A,B,C
+ <i>Lagorchestes asomatus</i>	Central Hare-wallaby	Australia	1931	
<i>Lagorchestes leporides</i>	Eastern Hare-wallaby	Australia	1890	
<i>Macropus greyi</i>	Toolache Wallaby	Australia	1927	C
<i>Onychogalea lunata</i>	Crescent Nailtail Wallaby	Australia	1984	C,D
<i>Potorous platyops</i>	Broad-faced Potoroo	Australia	1875	C
Family Peramelidae				
<i>Chaeropus ecaudatus</i>	Pig-footed Bandicoot	Australia	1907	C,D
<i>Perameles eremicana</i>	Desert Bandicoot	Australia	1935	
Family Thylacomyidae				
<i>Macrotis leucura</i>	Lesser Bilby	Australia	1931	A,C
Family Thylacinidae				
<i>Thylacinus cynocephalus</i>	Thylacine	Tasmania (Australia)	1934	E
Order CHIROPTERA				
Family Pteropodidae				
<i>Acerodon lucifer</i>	Panay Giant Fruit Bat	Philippines	1888	
<i>Dobsonia chapmani</i>	Chapman's Bare-backed Flying Fox	Philippines	1964	
<i>Pteropus pilosus</i>	Palau Flying Fox	Palau	19th C	
<i>Pteropus subniger</i>	Lesser Mascarene Flying Fox	Mauritius, Réunion		
<i>Pteropus tokudae</i>	Guam Flying Fox	Guam	1968	
Family Molossidae				
<i>Mystacinia robusta</i>	New Zealand Lesser Short-tailed Bat	New Zealand	1960s	
Order INSECTIVORA				
Family Nesophontidae				
# <i>Nesophontes hypomictus</i>	Atalaye Nesophontes	Haiti, Dominican Republic		C
# <i>Nesophontes micrus</i>	Western Cuban Nesophontes	Cuba		C
# <i>Nesophontes paramicrus</i>	St Michel Nesophontes	Haiti, Dominican Republic		C
# <i>Nesophontes zamirus</i>	Haitian Nesophontes	Haiti, Dominican Republic		C
# <i>Nesophontes sp.</i>		Cayman Is		
Order LAGOMORPHA				
Family Ochotonidae				
<i>Prolagus sardus</i>	Sardinian Pika	Corsica (France), Sardinia (Italy)	18th C	
Family Leporidae				
* <i>Sylvilagus insonus</i>	Ornithodoros Cottontail	Mexico		
Order RODENTIA				
Family Arvicolidae				
<i>Pitymys bavaricus</i>	Bavarian Pine Vole	Germany		
Family Capromyidae				
# <i>Capromys sp.</i>		Cayman Is		
# <i>Geocapromys colombianus</i>		Cuba		
<i>Geocapromys thoractus</i>		Little Swan I (Honduras)		
# <i>Geocapromys sp.</i>		Cayman Is	1950s	
# <i>Isolobodon portoricensis</i>		Haiti, Dominican Republic		
# <i>Plagiodontia veloxi</i>		Haiti, Dominican Republic		
Family Cricetidae				
<i>Megalomys desmarestii</i>	Martinique Rice Rat	Martinique	1902	
<i>Megalomys luciae</i>	St Lucia Rice Rat	Saint Lucia	19th C	
<i>Megaloryzomys curioi</i>		Galapagos (Ecuador)		
<i>Megaloryzomys sp.</i>		Galapagos (Ecuador)		
<i>Nesoryzomys darwini</i>	Santa Cruz Rice Rat	Galapagos (Ecuador)		
<i>Nesoryzomys sp.</i>		Galapagos (Ecuador)		

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Table 16.4 Animal species extinct since circa 1600 (continued)

SPECIES	ENGLISH NAME	DISTRIBUTION	LAST RECORDED	POSSIBLE CAUSE
MAMMALS (continued)				
* <i>Oryzomys vittus</i>	St Vincent Rice Rat	Saint Vincent	1897	
* <i>Peromyscus pembertoni</i>	Pemberton's Deer Mouse	Mexico		
Family Echimyidae				
# <i>Boromys offella</i>		Cuba		
# <i>Boromys torrei</i>		Cuba		
# <i>Brotomys voratus</i>		Haiti, Dominican Republic		
Family Muridae				
<i>Conilurus albipes</i>	Rabbit-eared Tree-rat	Australia	1875	
* <i>Crateromys paulus</i>	Ilin Bushy-tailed Cloud-rat	Philippines		
<i>Leporillus apicalis</i>	Lesser Stick-nest Rat	Australia	1933	
* <i>Notomys amplius</i>	Short-tailed Hopping-mouse	Australia	1894	
* <i>Notomys longicaudatus</i>	Long-tailed Hopping-mouse	Australia	1901	
+ <i>Notomys macrotis</i>	Big-eared Hopping-mouse	Australia	pre-1850	
+ <i>Notomys mordax</i>	Darling Downs Hopping-mouse	Australia	pre-1846	
+ <i>Pseudomys fieldi</i>	Alice Springs Mouse	Australia	1895	
+ <i>Pseudomys gouldi</i>	Gould's Mouse	Australia	1930	
<i>Rattus macleari</i>	Gould's Rat	Australia	1908	
<i>Rattus nativitatis</i>	Bulldog Rat	Christmas I (Australia)	1908	
		Christmas I (Australia)	1908	
Order CARNIVORA				
Family Canidae				
<i>Dusicyon australis</i>	Falkland Island Wolf	Falklands Is	1876	E
Family Procyonidae				
+ <i>Procyon gloveri</i>	Barbados Raccoon	Barbados		
Order PINNIPEDIA				
Family Phocidae				
<i>Monachus tropicalis</i>	Caribbean Monk Seal	Caribbean	1962	A
Order SIRENIA				
Family Dugongidae				
<i>Hydrodamalis gigas</i>	Steller's Sea Cow	Bering Straits ('USSR')	1768	A
Order PERISSODACTyla				
Family Equidae				
<i>Equus quagga</i>	Quagga	South Africa	1883	A,E
Order ARTIODACTYLA				
Family Bovidae				
<i>Gazella rufina</i>	Red Gazelle	Algeria?	19th C	A
<i>Hippotragus leucophaeus</i>	Bluebuck	South Africa	1800	E
Family Cervidae				
<i>Cervus schomburgkii</i>	Schomburgk's Deer	Thailand	1932	A

Key. * indicates species generally regarded as extinct but for which there may still be some chance of survival. + indicates taxa which may be conspecific with extant forms. # indicates species known from post-Columbian (i.e. post 1500) deposits in the Caribbean; some may have become extinct before 1600. . indicates species last recorded from Rapa in 1934, and which were considered likely to become rapidly extinct. x indicates species recorded from subfossil deposits in the Mascarenes which are considered very likely to have become extinct following settlement in 1723 although may possibly have become extinct earlier.

Possible causes column: A Hunting (includes for food, skin, sport, live trade, feathers); B Direct habitat alteration by man; C Introduced predators (e.g. cats, rats, mustelids, mongooses, snails, monkeys); (C/D predators or others not specified); D Other introduced animals (e.g. goats, rabbit, pigs); E Destroyed as a pest species; F Introduced disease; G Indirect effects; H Natural Causes; - causes uncertain.

Note: The proceedings of a symposium entitled *St Helena Natural Treasury* (Edited by P. Pearce-Kelly and Q.C.B. Cronk, published by the Zoological Society of London, 1990) were procured too late to include data in these lists. An additional eight extinct endemic bird species are listed from that island, six of which should be included in our analysis. They are thought to have become extinct as a result of the human discovery of the island in 1502, and should therefore be included in the same sort of category as those species recovered from post-Columbian deposits in the Caribbean (i.e. those marked #). The report would also seem to indicate that it may be premature to declare the two insects *Labidura herculeana* and *Apothorax burchelli* extinct, and they should perhaps be excluded from this list at present. The effect these additions and changes have on the graphs and maps should be borne in mind, especially the increase in early island bird extinctions.

Source: compiled from multiple sources; details available from WCMC. Most bird data compiled by A Stattersfield, and kindly made available by the International Council for Bird Preservation. Mollusc data assembled by Sue Wells with the assistance of members of the SSC Mollusc Specialist Group and other malacologists.

Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)	FAMILY	TAXON	COMMON NAME	HISTORIC RANGE
Fern Allies	Lycopodiaceae	<i>Huperzia nutans</i> Brackenr.		United States - Hawaii
	Selaginellaceae	<i>Selaginella orizabensis</i> Hieron.		Mexico - Veracruz
	Isoetaceae	<i>Isoetes dixitii</i> Shende <i>Isoetes sampathkumarnii</i> L.N. Rao		India - Maharashtra State India - Karnataka State
True Ferns	Asplidiaceae	<i>Diplazium leaffanianum</i> (Baker) C.Chr. <i>Dryopteris speluncae</i> (L.) Underwood <i>Lastreopsis wattii</i> (Beddome) Tagawa		Bermuda Bermuda India - Manipur State
	Aspleniaceae	<i>Asplenium fragile</i> K. Presl var. <i>insularis</i> C. Morton <i>Asplenium leucostegioides</i> Baker <i>Diellia manii</i> <i>Diellia unisora</i> Wagner		United States - Hawaii United States - Hawaii United States - Hawaii United States - Hawaii
	Blechnaceae	<i>Doodia lyoni</i> Degener		United States - Hawaii
	Marsileaceae	<i>Marsilea paradoxa</i> Diels		Australia - Western Australia
	Ophioglossaceae	<i>Botrychium subbifoliatum</i> Brackenr.	makou	United States - Hawaii
	Thelypteridaceae	<i>Christella altissima</i> Holttum <i>Thelypteris macilenta</i> E. St. John	Edward's maiden fern	South Africa - Natal United States - Florida
Gymnosperms	Zamiaceae	<i>Encephalartos woodii</i> Sander <i>Zamia monticola</i> Chamberlain		South Africa - Natal Mexico
Dicots	Acanthaceae	<i>Dicliptera abuensis</i> Blatter <i>Dicliptera falcata</i> (Lam.) Bosser & Heine <i>Hypoestes inconspicua</i> Balf. f. <i>Hypoestes rodriguesiana</i> Balf. f. <i>Hypoestes serpens</i> R. Br. <i>Justicia brachystachya</i> Thouars ex Schultz <i>Justicia eranthenoides</i> F. Muell. <i>Justicia psychotrioides</i> Thouars ex Schultz		India - Rajasthan State Mauritius Mauritius - Rodrigues Mauritius - Rodrigues Mauritius Mauritius Mauritius Australia - New South Wales Mauritius
	Aizoaceae	<i>Gibbaeum esterhuyseniae</i> L. Bolus <i>Trianthema cypseloides</i> (Fenzl) Benth.		South Africa - Cape Province Australia - New South Wales
	Amaranthaceae	<i>Achyranthes atollensis</i> St. John <i>Achyranthes mutica</i> A. Gray ex H. Mann <i>Amaranthus mentegazzianus</i> Passer. <i>Blutaparon rigidum</i> (Robinson & Greenman) Mears <i>Ptilotus caespitulosus</i> F. Muell. <i>Ptilotus extenuatus</i> Benth <i>Ptilotus fasciculatus</i> Fitzg. <i>Ptilotus pyramidatus</i> (Moq.) F. Muell.		United States - Hawaii United States - Hawaii Argentina Ecuador - Galapagos Australia - Western Australia Australia - New South Wales Australia - Western Australia Australia - Western Australia
	Anacardiaceae	<i>Buchanania mangoides</i> F. Muell.		Australia - Queensland
	Aquifoliaceae	<i>Ilex ternetiflora</i> (C. Wright) R.A. Howard		Cuba
	Asclepiadaceae	<i>Caralluma arenicola</i> N.E. Brown <i>Marsdenia coronata</i> Benth. <i>Marsdenia tubulosa</i> F. Muell. <i>Matelea balbisii</i> (Dcne.) Woods. <i>Matelea radiata</i> Correll	Balbis' milkvine Falfurrias Anglepod	South Africa - Cape Province Australia - Queensland Australia - NSW - Lord Howe Island United States - Arizona United States - Texas
	Begoniaceae	<i>Begonia cowellii</i> Nash <i>Begonia opuliflora</i> Putz.		Cuba Panama
	Boraginaceae	<i>Cryptantha aperta</i> (Eastw.) Payson <i>Cryptantha insolita</i> (J.F. Macbr.) Payson <i>Heliotropium muticum</i> Domin	Grand Junction cat's-eye unusual cat's-eye	United States - Colorado United States - Nevada Australia - Western Australia

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Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)		COMMON NAME	HISTORIC RANGE
FAMILY	TAXON		
	<i>Heliotropium pannifolium</i> Burchell ex Hemsley		St Helena
	<i>Lindelofia angustifolia</i> (Schrenk) A. Brand.		former Union of Soviet Socialist Republics
	<i>Myosotis petiolata</i> Hook.f. var. <i>pottsiiana</i> L. Moore		New Zealand - North Island
	<i>Onosma effine</i> Hausskn. ex H. Riedl		Turkey
	<i>Onosma discedens</i> Hausskn. ex Bornm.		Turkey
	<i>Plagiobothrys diffusus</i> (Greene) I.M. Johnston	San Francisco popcornflower	United States - California
	<i>Plagiobothrys lamprocarpus</i> (Piper) I.M. Johnston	popcornflower	United States - Oregon
	<i>Plagiobothrys orthostatus</i> J. Black		Australia - South Australia
Bruniaceae			
	<i>Staavia trichotoma</i> (Thunb.) Pillans		South Africa - Cape Province
	<i>Thamneea depressa</i> Oliver		South Africa - Cape Province
	<i>Thamneea uniflora</i> Solander ex Brongn.		South Africa - Cape Province
Cactaceae			
	<i>Hylocereus cubensis</i> Britton & Rose		Cuba
	<i>Leptocereus wrightii</i> Leon		Cuba
	<i>Lobivia vatteri</i> Krainz		Argentina
	<i>Opuntia lindheimeri</i> Engelmann var. <i>linguiformis</i> (Griffiths) L. Benson		United States - Texas
	<i>Pyrhocactus aricensis</i> Ritt.		Chile
	<i>Pyrhocactus longirama</i> Ritt.		Chile
	<i>Pyrhocactus nuda</i> Ritt.		Chile
	<i>Pyrhocactus occultus</i> Ritt.		Chile
Campanulaceae			
	<i>Campanula oligosperma</i> Damboldt		Turkey
	<i>Clermontia multiflora</i> Hillebrand		United States - Hawaii
	<i>Cyanea arborea</i> (H. Mann) Hillebrand var. <i>arborea</i>		United States - Hawaii
	<i>Cyanea asplenifolia</i> (H. Mann) Hillebrand	spleenwort-leaved cyanea	United States - Hawaii
	<i>Cyanea comata</i> Hillebrand		United States - Hawaii
	<i>Cyanea dunbarii</i> Rock		United States - Hawaii
	<i>Cyanea giffardii</i> Rock		United States - Hawaii
	<i>Cyanea glabra</i> (F. Wimmer) St. John	smooth cyanea	United States - Hawaii
	<i>Cyanea grimesiana</i> Gaudich. ssp. <i>cylindrocalyx</i> (Rock) Lammers		United States - Hawaii
	<i>Cyanea linearifolia</i> Rock		United States - Hawaii
	<i>Cyanea longissima</i> (Rock) St. John		United States - Hawaii
	<i>Cyanea obtusa</i> (A. Gray) Hillebrand		United States - Hawaii
	<i>Cyanea pohaku</i> Lammers		United States - Hawaii
	<i>Cyanea procera</i> Hillebrand		United States - Hawaii
	<i>Cyanea profuga</i> C. Forbes		United States - Hawaii
	<i>Cyanea pycnocarpa</i> (Hillebrand) F.E. Wimmer		United States - Hawaii
	<i>Cyanea quercifolia</i> (Hillebrand) F.E. Wimmer var. <i>quercifolia</i>		United States - Hawaii
	<i>Cyanea recta</i> (Wawra) Hillebrand		United States - Hawaii
	<i>Cyanea scabra</i> Hillebrand var. <i>longissima</i> Rock		United States - Hawaii
	<i>Cyanea undulata</i> C. Forbes		United States - Hawaii
	<i>Delissea fallax</i> Hillebrand		United States - Hawaii
	<i>Delissea laciniata</i> Hillebrand var. <i>laciniata</i>	cut-leaf delissea	United States - Hawaii
	<i>Delissea lauliana</i> Lammers		United States - Hawaii
	<i>Delissea parviflora</i> Hillebrand	small-flowered delissea	United States - Hawaii
	<i>Delissea rivularis</i> (Rock) F.E. Wimmer		United States - Hawaii
	<i>Delissea sinuata</i> Hillebrand ssp. <i>lanaiensis</i> (Rock) Lammers		United States - Hawaii
	<i>Delissea sinuata</i> Hillebrand var. <i>sinuata</i>	wavy-leaf delissea	United States - Hawaii
	<i>Delissea undulata</i> Gaudich.	undulata delissea	United States - Hawaii
	<i>Lobelia monostachya</i> (Rock) Lammers		United States - Hawaii
	<i>Lobelia remyi</i> Rock		United States - Hawaii
	<i>Rollandia parvifolia</i> C. Forbes		United States - Hawaii
	<i>Rollandia purpureifolia</i> Rock		United States - Hawaii
	<i>Wahlenbergia burchellii</i> A.DC.		St Helena
	<i>Wahlenbergia roxburghii</i> A.DC.		St Helena
	<i>Wahlenbergia saxifragoides</i> V. Brehm.		South Africa - Cape Province
Caryophyllaceae			
	<i>Alsinidendron viscosum</i> (H. Mann) Sherff		United States - Hawaii
	<i>Schiedea amplexicaulis</i> H. Mann		United States - Hawaii
	<i>Schiedea helleri</i> Sherff		United States - Hawaii
	<i>Schiedea implexa</i> (Hillebrand) Sherff		United States - Hawaii
	<i>Schiedea spergulina</i> A. Gray var. <i>leiopoda</i> Sherff		United States - Hawaii
	<i>Schiedea stellaroides</i> H. Mann var. <i>stellaroides</i>	Iaulihilihi; kawelu; ma'oli'oli	United States - Hawaii
	<i>Silene cryptopetala</i> Hillebrand		United States - Hawaii
	<i>Silene oligotricha</i> Huber-Mor.		Turkey
	<i>Silene rectiramea</i> Robinson		United States - Arizona

Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)	FAMILY	TAXON	COMMON NAME	HISTORIC RANGE
Celastraceae		<i>Stellaria elatinoides</i> Hook. f.		New Zealand
		<i>Hexaspore pubescens</i> C. White		Australia - Queensland
		<i>Meytenus lineata</i> C. Wright		Cuba
Chenopodiaceae		<i>Hemicroa mesembryanthema</i> F. Muell.		Australia - South Australia
		<i>Sclerolaena ramseyae</i> (Willis) A.J. Scott		Australia - Victoria
		<i>Suaeda duripes</i> I.M. Johnston	hardtoe seepweed	United States - Texas
Compositae		<i>Abrotanella rhynchospera</i> Balf. f.		Mauritius - Rodrigues
		<i>Acanthocladium dockeri</i> F. Muell.		Australia - New South Wales, South Australia
		<i>Argyroxiphium virescens</i> Hillebrand var. <i>virescens</i>	greensword	United States - Hawaii
		<i>Artemisia insipida</i> Vill.		France
		<i>Brachycome muelleri</i> Sonder		Australia - South Australia
		<i>Calocephalus globosus</i> M. Scott & Hutch.		Australia - Western Australia
		<i>Cirsium toyoshimae</i> Koidz.		Japan
		<i>Commidendrum rotundifolium</i> (Roxb.) DC.		St Helena
		<i>Crepidiastrum aristophyllum</i> (Koidz.) Nakai		Japan - Ogasawara-Shoto
		<i>Crepidiastrum grandicollum</i> (Koidz.) Nakai		Japan - Ogasawara-Shoto
		<i>Erigeron perglaber</i> Blake		United States - Arizona
		<i>Felicia annectens</i> (Harvey) Grau		South Africa - Cape Province
		<i>Helianthus praetermissus</i> E. Watson		United States - New Mexico
		<i>Helichrysum oligochaetum</i> F. Muell.		Australia - Western Australia
		<i>Helichrysum selaginoides</i> (Sonder & F. Muell.) Benth.		Australia - Tasmania
		<i>Helichrysum spiceri</i> F. Muell.		Australia - Tasmania
		<i>Helipterum guilfoylei</i> Ewart		Australia - Western Australia
		<i>Hemizonia mohavensis</i> Keck	Mojave tarweed; Mojave tarplant	United States - California
		<i>Leptorhynchos gatesii</i> (Williamson) J.H. Willis		Australia - Victoria
		<i>Lipochaeta bryani</i> Sheriff		United States - Hawaii
		<i>Lipochaeta ovata</i> R. Gardner		United States - Hawaii
		<i>Lipochaeta perdita</i> Sheriff	ko'oko'olau; nehe	United States - Hawaii
		<i>Marasmodes undulata</i> Compton		South Africa - Cape Province
		<i>Olearia arida</i> Pritzel		Australia - South Australia, Western Australia
		<i>Olearia flocktoniae</i> Maiden & E. Betcke		Australia - New South Wales
		<i>Olearia oligantha</i> Benth.		Australia - New South Wales
		<i>Osteospermum hirsutum</i> Thunb.		South Africa - Cape Province
		<i>Perityle inyoensis</i> (Ferris) A. Powell	Inyo laphamia	United States - California
		<i>Perityle villosa</i> (Blake) Shinn.	Hanaupah laphamia	United States - California
		<i>Senecio behrianus</i> Sonder & F. Muell.		Australia - New South Wales, South Australia, Victoria
		<i>Senecio georgianus</i> DC.		Australia - South Australia, Victoria, Western Australia
		<i>Senecio laticostatus</i> Belcher		Australia - Victoria
		<i>Senecio sandwicensis</i> Less.		United States - Hawaii
		<i>Solidago porteri</i> Small	Porter's goldenrod	United States - Georgia, North Carolina
		<i>Tetramolopium arenarium</i> (A. Gray) Hillebrand var. <i>arenarium</i>		United States - Hawaii
		<i>Tetramolopium arenarium</i> (A. Gray) Hillebrand var. <i>confertum</i> Sheriff		United States - Hawaii
		<i>Tetramolopium arenarium</i> (A. Gray) Hillebrand ssp. <i>laxum</i> Lowrey		United States - Hawaii
		<i>Tetramolopium capillare</i> (Gaudich.) H. St. John		United States - Hawaii
		<i>Tetramolopium consanguineum</i> (A. Gray) Hillebrand ssp. <i>consanguineum</i>		United States - Hawaii
		<i>Tetramolopium conyzoides</i> (A. Gray) Hillebrand		United States - Hawaii
		<i>Tetramolopium lepidotum</i> Less. ssp. <i>arbusculum</i> (A. Gray) T.K. Lowrey		United States - Hawaii
		<i>Tetramolopium tenerimum</i> (Less.) Nees		United States - Hawaii
		<i>Tracyina rostrata</i> Blake	showy indian clover	United States - California
		<i>Vernonia africana</i> (Sonder) Druce		South Africa - Natal
Crassulaceae		<i>Crassula alicornis</i> Schonl.		South Africa - Cape Province
		<i>Crassula subulata</i> Hermann var. <i>hispida</i> (Schonl. & E.G. Baker) Toelken		South Africa - Cape Province
		<i>Echeveria laui</i> Moran & Meyran		Mexico - Oaxaca
		<i>Sedum pinetorum</i> Brandegee	Pine City stonecrop	United States - California
		<i>Sedum polystriatum</i> R.T. Clausen		Turkey
		<i>Tacitus bellus</i> Moran & Meyran		Mexico - Chihuahua
Cruciferae				

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Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)	FAMILY	TAXON	COMMON NAME	HISTORIC RANGE
		<i>Ballantinia antipoda</i> (F. Muell.) E. Shaw		Australia - Tasmania, Victoria
		<i>Caulanthus lemmonii</i>		United States - Arizona
		<i>Diplotaxis siettiana</i> Maire		Spain
		<i>Hutchinsia tasmanica</i> Hook.		Australia - Tasmania
		<i>Isetis arnoldiana</i> N. Busch.		former Union of Soviet Socialist Republics
		<i>Lepidium drummondii</i> Thell.		Australia - Western Australia
		<i>Lepidium merrallii</i> F. Muell.		Australia - Western Australia
		<i>Lepidium obtusatum</i> Kirk		NEW ZEALAND - North Island
		<i>Lepidium peregrinum</i> Thell.		Australia - New South Wales
		<i>Menkea draboides</i> (Hook.f.) Benth.		Australia - Western Australia
		<i>Phlegmatospermum drummondii</i> (Benth.) O. Schultz		Australia - Western Australia
		<i>Phlegmatospermum richardsii</i> (F. Muell.) E. Shaw		Australia - South Australia, Western Australia
		<i>Rorippa coloradensis</i> Stuckey	Colorado watercress	United States - Colorado
		<i>Stroganowia sagittata</i> Karelkin & Kir.		Asiatic former Union of Soviet Socialist Republics
		<i>Tropidocarpum capparideum</i> Greene	caper-fruited tropidocarpum	United States - California
	Cucurbitaceae	<i>Benincasa hispida</i> (Thunb.) Cogn.		Australia - Queensland
		<i>Sicyos hillebrandii</i> H. St. John		United States - Hawaii
		<i>Sicyos villosa</i> Hook. f.		Ecuador - Galapagos
	Dicrystylidaceae	<i>Dicrystylis morrisonii</i> Munir		Australia - Western Australia
	Dilleniaceae	<i>Hibbertia sargentii</i> S. Moore		Australia - Western Australia
	Epacridaceae	<i>Andersonia bifida</i> L. Watson		Australia - Western Australia
		<i>Andersonia longifolia</i> (Benth.) L. Watson		Australia - Western Australia
		<i>Choristemon humilis</i> Williamson		Australia - Victoria
		<i>Coleanthera coelophylla</i> (DC.) Benth.		Australia - Western Australia
		<i>Coleanthera virgata</i> Stschegl.		Australia - Western Australia
		<i>Leucopogon cryptanthus</i> Benth.		Australia - Western Australia
		<i>Leucopogon pogonocalyx</i> Benth.		Australia - Western Australia
	Ericaceae	<i>Arctostaphylos uva-ursi</i> (L.) Sprengel var. <i>franciscana</i> (Eastw.) Roof		United States - California
		<i>Arctostaphylos uva-ursi</i> (L.) Sprengel var. <i>leobreveri</i> Roof		United States - California
		<i>Erica acockii</i> Compton		South Africa - Cape Province
		<i>Erica bolusiae</i> Salter		South Africa - Cape Province
		<i>Erica jasminiflora</i> Salisb.		South Africa - Cape Province
		<i>Erica pyramidalis</i> Solander		South Africa - Cape Province
		<i>Erica turgida</i> Salisb.		South Africa - Cape Province
		<i>Erica verticillata</i> Bergius		South Africa - Cape Province
		<i>Rhododendron mucronulatum</i> Turcz. var. <i>albiflora</i>		Republic of Korea
		Nakai		
	Erythroxylaceae	<i>Erythroxylum echinodendron</i> Ekman		Cuba
	Euphorbiaceae	<i>Acalypha rubra</i> Roxb.		St Helena
		<i>Amperea protensa</i> Nees		Australia - Western Australia
		<i>Beyeria cygnorum</i> (Muell. Arg.) Benth.		Australia - Western Australia
		<i>Beyeria lepidopetala</i> F. Muell.		Australia - Western Australia
		<i>Bonania myrciifolia</i> (Griseb.) Benth. & Hook.		Cuba
		<i>Chamaesyce celastroides</i> (Boiss.) Croizat & Degener var. <i>tomentella</i>	'akoko; koko; 'ekoko; kokomalei	United States - Hawaii
		<i>Cleoxylon grandifolium</i> (Poiret) Muell. Arg.		Mauritius; France - Reunion
		<i>Cnidoscolus fragrans</i> (H.B.K.) Pohl		Cuba
		<i>Croton magneticus</i> Airy Shaw		Australia - Queensland
		<i>Euphorbia carissoides</i> Bailey		Australia - Queensland
		<i>Euphorbia daphnooides</i> Balf. f.		Mauritius - Rodrigues
		<i>Pseudanthus nemetophorus</i> F. Muell.		Australia - Western Australia
	Fagaceae	<i>Quercus boytoni</i> Beadle	Boyton's sand post oak	United States - Texas
	Frankeniaceae	<i>Frankenia conferta</i> Diels		Australia - Western Australia
		<i>Frankenia decurrens</i> Summerh.		Australia - Western Australia
		<i>Frankenia parvula</i> Turcz.		Australia - Western Australia
	Gesneriaceae	<i>Cyrtandra cyanoides</i> Rock		United States - Hawaii

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FAMILY

TAXON	COMMON NAME	HISTORIC RANGE
<i>Cyrtandra gracilis</i> Hillebrand		United States - Hawaii
<i>Cyrtandra honolulensis</i> Wawra		United States - Hawaii
<i>Cyrtandra kohalaec</i> Rock		United States - Hawaii
<i>Cyrtandra olona</i> C. Forbes		United States - Hawaii
<i>Cyrtandra pickeringii</i> A. Gray var. <i>pickeringii</i>		United States - Hawaii
<i>Cyrtandra waianaei</i> Wawra var. <i>capitata</i> Hillebrand		United States - Hawaii
<i>Cyrtandra waianaei</i> Wawra var. <i>waianaei</i>	ha'iwale; kanawao ke'oke'o	United States - Hawaii
Goodeniaceae		
<i>Dampiera helmsii</i> Krause		Australia - Western Australia
<i>Dampiera humilis</i> (F. Muell.) E. Pritzel		Australia - Western Australia
<i>Dampiera rupicola</i> S. Moore		Australia - Western Australia
<i>Goodenia clementii</i> Krause		Australia - Western Australia
<i>Scaevola attenuata</i> R. Br.		Australia - Western Australia
<i>Scaevola macrophylla</i> (Vriese) Benth.		Australia - Western Australia
<i>Scaevola oldfieldii</i> F. Muell.		Australia - Western Australia
<i>Verreauxia verreauxii</i> (Vriese) Carolin		Australia - Western Australia
Grossulariaceae		
<i>Ribes kolymense</i> (Trautv.) Komarov ex Pojark		former Union of Soviet Socialist Republics
Haloragaceae		
<i>Gonocarpus intricatus</i> (Benth.) Orch.		Australia - Western Australia
<i>Haloragis stricta</i> R. Br.		Australia - New South Wales, Queensland
<i>Haloragis tenuifolia</i> Benth.		Australia - Western Australia
<i>Haloragodendron lucasii</i> (Maiden & E. Betch) Orch.		Australia - New South Wales
<i>Meziella trifida</i> (Nees) Schindler		Australia - Western Australia
Hydrophyllaceae		
<i>Phacelia amabilis</i> Constance	Saline Valley phacelia	United States - California
<i>Phacelia cinerea</i> Eastw.	ashy phacelia	United States - California
<i>Phacelia nevadensis</i> J. Howell	Nevada phacelia	United States - Nevada
Labiatae		
<i>Haplostachys bryani</i> Sherff var. <i>bryani</i>		United States - Hawaii
<i>Haplostachys linearifolia</i> (Drake) Sherff var. <i>linearifolia</i>		United States - Hawaii
<i>Haplostachys munroi</i> C. Forbes		United States - Hawaii
<i>Haplostachys truncata</i> (A. Gray) Hillebrand		United States - Hawaii
<i>Hemigenia exilis</i> S. Moore		Australia - Western Australia
<i>Hemigenia obtusa</i> Benth.		Australia - Western Australia
<i>Hemigenia pimelifolia</i> F. Muell.		Australia - Western Australia
<i>Hemigenia podalyrina</i> F. Muell.		Australia - Western Australia
<i>Hemigenia ramosissima</i> Benth.		Australia - Western Australia
<i>Hemigenia tysonii</i> F. Muell.		Australia - Western Australia
<i>Hemigenia tysonii</i> F. Muell.		Australia - Western Australia
<i>Microcorys pimeloides</i> F. Muell.		Australia - Western Australia
<i>Monardella leucocephala</i> A. Gray	Merced monardella	United States - California
<i>Monardella pringlei</i> A. Gray	Pringle monardella	United States - California
<i>Phyllostegia brevidens</i> A. Gray var. <i>brevidens</i>		United States - Hawaii
<i>Phyllostegia hillebrandii</i> Mann ex Hillebrand		United States - Hawaii
<i>Phyllostegia immunata</i> (Sherff) St. John		United States - Hawaii
<i>Phyllostegia knudsenii</i> Hillebrand		United States - Hawaii
<i>Phyllostegia rockii</i> Sherff		United States - Hawaii
<i>Phyllostegia variabilis</i> Bitter		United States - Hawaii
<i>Phyllostegia wawraea</i> Sherff		United States - Hawaii
<i>Prostanthera staurophylla</i> F. Muell.		Australia - New South Wales
<i>Pycnanthemum monotrichum</i> Fern.	mountain mint	United States - Virginia
<i>Stenogyne cinerea</i> Hillebrand		United States - Hawaii
<i>Stenogyne haliakalae</i> Wawra		United States - Hawaii
<i>Stenogyne oxygona</i> Degener & Sherff		United States - Hawaii
<i>Stenogyne viridis</i> Hillebrand		United States - Hawaii
<i>Teucrium leucophyllum</i> Montbret & Aucher ex Bentham		Turkey
<i>Thymus oehmianus</i> Ronn. & Soska		Yugoslavia
Lauraceae		
<i>Cassytha pedicellosa</i> J.Z. Webb		Australia - Tasmania
Leguminosae		
<i>Acacia forrestiana</i> E. Pritzel		Australia - Western Australia
<i>Acacia murruboensis</i> Maiden & Blakely		Australia - New South Wales
<i>Acacia prismifolia</i> E. Pritzel		Australia - Western Australia
<i>Acacia vassalii</i> Maslin		Australia - Western Australia
<i>Aspalathus variegata</i> Ecklon & Zeyher		South Africa - Cape Province
<i>Astragalus pseudocyclindraceus</i> Bornm.		Turkey
<i>Astragalus Robbinsii</i> (Oakes) A. Gray var. <i>robbinsii</i>		United States - Vermont

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Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)		COMMON NAME	HISTORIC RANGE
FAMILY	TAXON		
	<i>Chorizema varium</i> Benth.		Australia - Western Australia
	<i>Crotalaria urbaniana</i> Senn		Cuba
	<i>Gastrolobium crispifolium</i> Domin		Australia - Western Australia
	<i>Genista melia</i> Boiss.		Greece
	<i>Jacksonia hemisericcea</i> D. Herbert		Australia - Western Australia
	<i>Lathyrus dominianus</i> Litv.		former Union of Soviet Socialist Republics
	<i>Lupinus sublenatus</i> Eastw.	Santa Catalina Island desert-thorn	United States - California
	<i>Mirbelia densiflora</i> C. Gardner		Australia - Western Australia
	<i>Onobrychis aliacmonia</i> Reich. f.		Greece
	<i>Orbexilum macrophyllum</i> Rydb.		United States - North Carolina
	<i>Oxylobium acutum</i> (Benth.) Benth.		Australia - Western Australia
	<i>Phyllota gracilis</i> Turcz.		Australia - Western Australia
	<i>Psoralea macrophylla</i> Rowlee ex Small	bigleaf scurpea	United States - North Carolina
	<i>Psoralea stipulata</i> Torrey ex A. Gray	scurf-pea	United States - Indiana, Kentucky
	<i>Pultenaea pauciflora</i> M. Scott		Australia - Western Australia
	<i>Sophora toromiro</i> (Philippi) Skottsb.	toromiro	Chile - Easter Island
	<i>Strebloorrhiza speciosa</i> Endl.		Australia - Norfolk Island
	<i>Taverniera sericophylla</i> Balf. f.		Democratic Yemen - Socotra
	<i>Tephrosia kassasi</i> Boulos		Egypt
	<i>Tetragonolobus wiedemannii</i> Boiss.		Greece
	<i>Trifolium amoenum</i> E. Greene	showy indian clover	United States - California
	<i>Vicia dennessiana</i> H.C. Watson		Portugal - Azores
Lentibulariaceae	<i>Utricularia meirii</i> Cheeseman		New Zealand - North Island
Loasaceae	<i>Mentzelia nitens</i> Greene var. <i>leptocaulis</i> J. Darl.		United States - Arizona
Loganiaceae	<i>Mitrasacme palustris</i> W. Fitzg.		Australia - Western Australia
Loranthaceae	<i>Dendrophthora terminalis</i> Kuijt		Costa Rica
	<i>Psittacanthus nudus</i> (A. Molina) Kuijt & Feuer		Honduras
	<i>Trilepidea adamsii</i> (Cheeseman) Tieghem		New Zealand - North Island
Malvaceae	<i>Abutilon mauritianum</i> (Jacq.) Medik.		Mauritius
	<i>Anisodontea alexandri</i> (Baker f.) Bates		South Africa - Cape Province
	<i>Hibiscadelphus bombycinus</i> C. Forbes		United States - Hawaii
	<i>Hibiscadelphus cruciataeetus</i> Hobdy		United States - Hawaii
	<i>Hibiscadelphus wilderianus</i> Rock		United States - Hawaii
	<i>Hibiscus nelsonii</i> Rose & Standley		Mexico
	<i>Kokia lanceolata</i> Lewton		United States - Hawaii
	<i>Malacothamnus abbottii</i> (Eastw.) Kearney	Abbott's bush-mallow	United States - California
	<i>Malacothamnus mendocinensis</i> (Eastw.) Kearney	Mendocino bush-mallow	United States - Arkansas, California
	<i>Sida pritzelii</i> C. Gardner		Australia - Western Australia
	<i>Sidalcea keckii</i> Wiggins	Keck sidalcea; Keck checker-mallow	United States - California
	<i>Sphaeralcea procera</i> C.L. Porter	Luna County globemallow	United States - New Mexico
Menispermaceae	<i>Hyperbaena obovata</i> Urban		Cuba
Menyanthaceae	<i>Nymphoides stygia</i> (J. Black) H. Eichler		Australia - South Australia
Myoporaceae	<i>Eremophila adenotricha</i> F. Muell.		Australia - Western Australia
	<i>Eremophila scaberula</i> Fitzg.		Australia - Western Australia
Myrsinaceae	<i>Badula ovalifolia</i> A.DC.		France - Reunion
	<i>Myrsine mezii</i> Hosaka		United States - Hawaii
Myrtaceae	<i>Calothamnus blepharantherus</i> F. Muell.		Australia - Western Australia
	<i>Hypocalymma longifolium</i> F. Muell.		Australia - Western Australia
	<i>Melaleuca arenaria</i> C. Gardner		Australia - Western Australia
	<i>Melaleuca arenicola</i> S. Moore		Australia - Western Australia
	<i>Melaleuca graminea</i> S. Moore		Australia - Western Australia
	<i>Monimiastrum fasciculatum</i> Gueho & A.J. Scott		Mauritius
	<i>Syzygium balfourii</i> (Baker) Gueho & A.J. Scott		Mauritius - Rodrigues
	<i>Verticordia carinata</i> Turcz.		Australia - Western Australia
Nyctaginaceae	<i>Pisonia floridana</i> Britton	rock dove devil's-claws	United States - Florida
Ochnaceae	<i>Ouratea alternifolia</i> (A. Rich.) M. Gomez		Cuba
Oleaceae	<i>Hesperelia palmeri</i> A. Gray		Mexico
Onagraceae			

Table 16.5 Extinct higher plant taxa***MAJOR GROUP (DIVISION)****FAMILY**

TAXON	COMMON NAME	HISTORIC RANGE
<i>Clarkia mosquinii</i> E. Small ssp. <i>xerophila</i> E. Small		United States - California
<i>Lopezia conjugens</i> Brandegee		Mexico
<i>Lopezia sinaloensis</i> Munz		Mexico
<i>Oenothera kleinii</i> W.L. Wagner & S.W. Mill	Klein's evening-primrose; Wolf Creek evening-primrose	United States - Colorado
Papaveraceae		
<i>Eschscholzia rhombipetala</i> E. Greene	diamond-petaled; California poppy	United States - California
Penaeaceae		
<i>Stylapterus micranthus</i> R. Dahlgren		South Africa - Cape Province
Piperaceae		
<i>Peperomia degeneri</i> Yuncker		United States - Hawaii
<i>Peperomia hirta</i> Balf. f.		Mauritius - Rodrigues
<i>Peperomia rodriguezi</i> Balf. f.		Mauritius - Rodrigues
<i>Peperomia rossii</i> Rendle		Australia - Christmas Island
Plumbaginaceae		
<i>Armeria arcuata</i> Welw. ex Boiss. & Reuter		Portugal
Polygalaceae		
<i>Comesperma lanceolatum</i> Benth.		Australia - Western Australia
<i>Comesperma rhadinocarpum</i> F. Muell.		Australia - Western Australia
Polygonaceae		
<i>Eriogonum truncatum</i> Torrey & A. Gray	Contra Costa eriogonum; Mt Diablo buckwheat	United States - California
Portulacaceae		
<i>Calandrinia composita</i> Nees		Australia - Western Australia
<i>Calandrinia dielsii</i> Poelln.		Australia - Western Australia
<i>Calandrinia feltonii</i> Scottsb.		Falkland Islands
<i>Calandrinia sphaerophylla</i> J. Black		Australia - South Australia
Primulaceae		
<i>Lysimachia forbesii</i> Rock		United States - Hawaii
<i>Lysimachia minoricensis</i> J.D. Rodriguez		Spain - Balearic Islands
Proteaceae		
<i>Grevillea batrachoides</i> McGillivray		Australia - Western Australia
<i>Grevillea divaricata</i> R. Br.		Australia - New South Wales
<i>Grevillea flexuosa</i> (Lindley) Meissner		Australia - Western Australia
<i>Grevillea scabra</i> Meissner		Australia - Western Australia
<i>Hakea crassinervia</i> Meissner		Australia - Western Australia
<i>Hakea pulvinifera</i> L. Johnson		Australia - Western Australia
<i>Hakea tamminensis</i> C. Gardner		Australia - New South Wales
<i>Isopogon uncinatus</i> R. Br.		Australia - Western Australia
<i>Leucadendron comosum</i> (Thunb.) R. Br. ssp. <i>homoeophyllum</i> (Meisn.) I. Williams		Australia - Western Australia
<i>Leucadendron spirale</i> (Salisb. ex Knight) I. Williams		South Africa - Cape Province
<i>Mimetes stokoei</i> Phillips & Hutch.		South Africa - Cape Province
<i>Persoonia leucopogon</i> S. Moore		Australia - Western Australia
<i>Sorocephalus tenuifolius</i> R. Br.		South Africa - Cape Province
<i>Triunia robusta</i> (C. White) D. Foreman		Australia - Queensland
Pyrolaceae		
<i>Pyrola oxypetala</i> Austin	sharp-petal wintergreen	United States - New York
Rhamnaceae		
<i>Cryptandra tubulosa</i> Fenzl.		Australia - Western Australia
<i>Cryptandra uncinata</i> Grun.		Australia - South Australia
<i>Spyridium kalganense</i> Diels		Australia - Western Australia
<i>Spyridium microcephalum</i> (Turcz.) Benth.		Australia - Western Australia
<i>Trymalium albicans</i> (Steudel) Reisseck		Australia - Western Australia
<i>Trymalium urceolare</i> (F. Muell.) Diels		Australia - Western Australia
Rosaceae		
<i>Potentilla multijuga</i> Lehm.	Ballona cinquefoil	United States - California
Rubiaceae		
<i>Danais corymbosa</i> Balf. f.		Mauritius - Rodrigues
<i>Gaertnera calycina</i> Bojer		Mauritius
<i>Gaertnera crassiflora</i> Bojer		Mauritius
<i>Gaertnera longifolia</i> Bojer var. <i>pubescens</i> Verdc.		Mauritius
<i>Gaertnera quadrifida</i> A.DC.		Mauritius
<i>Hedyotis foliosa</i> (Hillebrand) Fosb.		United States - Hawaii
<i>Oldenlandia adscensionis</i> (DC.) Cronk		Ascension Island
<i>Oldenlandia polyclada</i> (F. Muell.) F. Muell.		Australia - Queensland
<i>Oldenlandia sieberi</i> Baker var. <i>sieberi</i>		Mauritius
<i>Opercularia hirsuta</i> F. Muell ex Benth.		Australia - Western Australia
<i>Opercularia ocolytantha</i> Diels.		Australia - Western Australia
<i>Ophiorrhiza brunonis</i> Wight & Arn.		India - Karnataka State, Kerala State, Tamil Nadu State
<i>Ophiorrhiza caudata</i> C. Fischer		India - Kerala State

1. Biological Diversity

Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)	FAMILY	TAXON	COMMON NAME	HISTORIC RANGE
		<i>Ophiorrhiza radicans</i> Gardn.		India - Kerala State; Sri Lanka
		<i>Phyllecanthus grisebachianus</i> Hook. f.		Cuba
		<i>Psychotria baneana</i> Urban		Cuba
		<i>Pyrostria ferruginea</i> Verdc.		Mauritius
		<i>Rondeletia odorata</i> Jacq. var. <i>breviflora</i> Hook.		Panama
		<i>Wendlandia angustifolia</i> Wight		India - Tamil Nadu State
Rutaceae		<i>Acmaedia candida</i> I. Williams		South Africa - Cape Province
		<i>Agathosma orbicularis</i> Bartl. & Wendl. f.		South Africa - Cape Province
		<i>Eriostemon falcatus</i> P.G. Wilson		Australia - Western Australia
		<i>Galipea ossana</i> DC.		Cuba
		<i>Kodalydendron cubensis</i> Borth. & Acuna		Cuba
		<i>Melicope adscendens</i> (St. John & Hume) T. Hartley & B. Stone		United States - Hawaii
		<i>Melicope ballouii</i> (Rock) T. Hartley & B. Stone		United States - Hawaii
		<i>Melicope degeneri</i> (B. Stone) T. Hartley & B. Stone		United States - Hawaii
		<i>Melicope lydgatei</i> (Hillebrand) T. Hartley & B. Stone		United States - Hawaii
		<i>Melicope ovalis</i> (St. John) T. Hartley & B. Stone		United States - Hawaii
		<i>Melicope quadrangularis</i> (St. John & E. Hume) T. Hartley & B. Stone		United States - Hawaii
		<i>Melicope reflexa</i> (St. John) T. Hartley & B. Stone		United States - Hawaii
		<i>Melicope weilauensis</i> (St. John) T. Hartley & B. Stone		United States - Hawaii
		<i>Pelea fatuhivensis</i> F. Brown		France - French Polynesia - Marquesas Is
		<i>Pelea obovata</i> H. St. John		United States - Hawaii
		<i>Phebalium daviesii</i> Hook. f.		Australia - Tasmania
		<i>Phebalium lachnaeoides</i> Cunn.		Australia - New South Wales
		<i>Zanthoxylum leonis</i> Alain		Cuba
		<i>Ziera adenophora</i> Blakely		Australia - New South Wales
Santalaceae		<i>Leptomeria dielsiana</i> Pilger		Australia - Western Australia
		<i>Santalum fernandezianum</i> F. Philippi		Chile - Juan Fernandez
Sapindaceae		<i>Euchorium cubense</i> Ekman & Radlk.		Cuba
Saxifragaceae		<i>Astilbe crenatiloba</i> (Britton) Small	crenate-lobed false goat's-beard	United States - North Carolina, Tennessee
		<i>Mitella prostrata</i> Michaux		Canada
		<i>Saxifrage lactea</i> Turcz.		former Union of Soviet Socialist Republics
		<i>Saxifraga oppositifolia</i> L. ssp. <i>amphibia</i> (Sunderm.) Braun-Blanquet		Germany; Switzerland
Scrophulariaceae		<i>Agalinis stenophylla</i> Pennell	narrow-leaved false foxglove	United States - Florida
		<i>Agalinis strictifolia</i> Pennell		United States - Louisiana
		<i>Castilleja cruenta</i> Standley	indian paintbrush	United States - Arizona
		<i>Castilleja leschkeana</i> J. Howell	Point Reyes indian paintbrush	United States - California
		<i>Euphrasia arguta</i> R. Br.		Australia - New South Wales
		<i>Euphrasia collina</i> R.Br. ssp. <i>muellieri</i> (Wettst.) Barker		Australia - New South Wales, South Australia, Victoria
		<i>Limosella pubiflora</i> Pennell	mudwort	United States - Arizona
		<i>Micranthemum micranthemosides</i> (Nutt.) Wettst.	Nuttall's micranthemum	United States - Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia
		<i>Mimulus brandegei</i> Pennell		United States - California
		<i>Mimulus clementii</i> Domin		Australia - Western Australia
		<i>Mimulus traskiae</i> A.L. Grant		United States - California
		<i>Mimulus whipplei</i> A.L. Grant		United States - California
		<i>Orthocarpus pachystachyus</i> A. Gray		United States - California
		<i>Penstemon leptanthus</i> Pennell		United States - Utah
		<i>Penstemon pulchellus</i> Lindl.		United States - New Mexico
		<i>Seymeria havardii</i> (Pennell) Stand		United States - Texas
		<i>Verbascum calycosum</i> Hausskn. & Murb.		Turkey
		<i>Veronica euxina</i> Turrill		Bulgaria
Solanaceae		<i>Lycium hassei</i> Greene		United States - California
		<i>Mellissia begonifolia</i> (Roxb.) Hook. f.		St Helena
		<i>Solenum bahamense</i> L. var. <i>rugelii</i> D'Arcy		United States - Florida
		<i>Solenum bauerianum</i> Endl.		Australia - NSW
				Lord Howe Island
				Australia - Norfolk Island

MAJOR GROUP (DIVISION)

FAMILY

TAXON	COMMON NAME	HISTORIC RANGE
<i>Solanum cajamaricense</i> Ochoa		Peru
<i>Solanum neve</i> Webb & Berthel.		Spain - Canary Islands
Sterculiaceae		
<i>Astiria rosea</i> Lindley		Mauritius
<i>Sterculia khasiana</i> Deb.		India - Meghalaya State
<i>Trochetia parviflora</i> Bojer ex Baker		Mauritius
Styliadiaceae		
<i>Stylium merrallii</i> (F.Muell.) E. Pritzl		Australia - Western Australia
<i>Stylium neglectum</i> Mildbr.		Australia - Western Australia
<i>Stylium pseudocaespitosum</i> Mildbr.		Australia - Western Australia
Styracaceae		
<i>Styrax portoricensis</i> Krug & Urban		Puerto Rico
Theaceae		
<i>Franklinia alatamaha</i> Marshall	Franklin tree	United States - Georgia
Tremandraceae		
<i>Tetraetheca deltoidea</i> J. Thompson		Australia - Western Australia
<i>Tetraetheca elliptica</i> J. Thompson		Australia - Western Australia
<i>Tetraetheca fasciculata</i> J. Thompson		Australia - Western Australia
<i>Tetraetheca gunnii</i> Hook. f.		Australia - Tasmania
Umbelliferae		
<i>Geocaryum bornmuelleri</i> (Wolff) Engstr.		Greece
<i>Geocaryum divaricatum</i> (Boiss. & Orph.) Engstr.		Greece
<i>Platysace dissecta</i> (Benth.) Norman		Australia - Western Australia
<i>Platysace eatoniae</i> (F. Muell.) Norman		Australia - Western Australia
<i>Trachymene croniiniana</i> F. Muell.		Australia - Western Australia
<i>Xanthosia singuliflora</i> F. Muell.		Australia - Western Australia
<i>Zizia latifolia</i> Small	bristol golden alexanders	United States - Florida
Urticaceae		
<i>Pilea thouarsiana</i> Wedd.		Mauritius
<i>Pilea trilobata</i> (Poiret) Wedd.		Mauritius
Valerianaceae		
<i>Valeriana pratensis</i> (Benth.) Steud.		Mexico
Violaceae		
<i>Isodendron pyrifolium</i> A. Gray	wahine noho kula	United States - Hawaii
<i>Viola cryana</i> Gillot		France
Zygophyllaceae		
<i>Fagonia taeckholmiana</i> Hadidi		Egypt

Monocots

Amaryllidaceae

<i>Caliphruria tenera</i> Baker	Colombia
<i>Eucharis lehmannii</i> Regel	Colombia
<i>Eucrosia mirabilis</i> (Baker) Pax	Ecuador
<i>Gethyllis esterhuyseniae</i>	South Africa - Cape Province
<i>Gethyllis latifolia</i> Masson ex Baker	South Africa - Cape Province
<i>Habranthus caeruleus</i> (Griseb.) Traub	Argentina
<i>Methieuia galanthoides</i> Klotzsch	Peru
<i>Plagiolaria horsmannii</i> Baker	Colombia

Araceae

<i>Anthurium leuconeurmum</i> Lemaire	Mexico
<i>Philodendron clementis</i> C.Wright ex Griseb.	Cuba

Burmanniaceae

<i>Thismia americana</i> N. Pfeiffer	United States - Illinois
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Centrolepidaceae

<i>Centrolepis caespitosa</i> D. Cooke	Australia - Western Australia
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Commelinaceae

<i>Seuvellaea blainii</i> C. Wright	Cuba
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Cyperaceae

<i>Bulbostylis neglecta</i> (Hemsley) C.B. Clarke	St Helena
<i>Carex aboriginum</i> M.E. Jones	United States - Idaho
<i>Carex paupera</i> Nelmes	Australia - Victoria
<i>Carex repanda</i> C.B. Clarke	India - Meghalaya State
<i>Cleidium drummondii</i> C.B. Clarke	Australia - Western Australia
<i>Eleocharis bermudiana</i> Britton	Bermuda
<i>Fimbristylis compacta</i> Turrill	Australia - Northern Territory
<i>Schoenus acuminatus</i> R. Br.	Australia - Western Australia
<i>Schoenus natans</i> (F. Muell.) Benth.	Australia - Western Australia
<i>Tetraeria australiensis</i> C.B. Clarke	Australia - Western Australia

Dioscoreaceae

<i>Dioscorea pentaphylla</i> L.	Australia - Queensland
<i>Rajania prestoniensis</i> Knuth	Cuba

Eriocaulaceae

<i>Eriocaulon echinospermoideum</i> Ruhl.	Cuba
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Biological Diversity

Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)	FAMILY	TAXON	COMMON NAME	HISTORIC RANGE
		<i>Eriocaulon johnstonii</i> Ruhl.		Mauritius
		<i>Eriocaulon minutissimum</i> Ruhl.		Cuba
		<i>Lechnocaulon cubense</i> Ruhl.		Cuba
Gramineae		<i>Agrostis adamsonii</i> Vick.		Australia - Victoria
		<i>Agrostis limitanea</i> J. Black		Australia - South Australia
		<i>Bromus brachystachys</i> Hornung		Germany
		<i>Bromus bromoideus</i> (Lej.) Crepin		Belgium
		<i>Bromus grossus</i> Desf. ex DC.		Belgium; Luxembourg
		<i>Bromus interruptus</i> (Hackel) Druce		United Kingdom
		<i>Cenchrus agrimonoides</i> Trin. var. <i>laysanensis</i> F.	kamanomano; kumanomano	United States - Hawaii
	Brown			
		<i>Deyeuxia drummondii</i> (Steudel) Vick.		Australia - Western Australia
		<i>Deyeuxia lawrencei</i> Vick.		Australia - Tasmania
		<i>Digitaria pittieri</i> (Hackel) Henrard		Costa Rica
		<i>Dissanthelium californicum</i> (Nutt.) Benth.	California dissanthelium	United States - California; Mexico
		<i>Eragrostis deflexa</i> Hitchc.	Pacific lovegrass	United States - Hawaii
		<i>Eragrostis fosbergii</i> Whitney	Fosberg's lovegrass	United States - Hawaii
		<i>Eragrostis hosakai</i> Degener		United States - Hawaii
		<i>Eragrostis mauensis</i> Hitchc.		United States - Hawaii
		<i>Eragrostis rottleri</i> Stapf		India - Tamil Nadu State
		<i>Eriochrysis rangacharii</i> Fischer		India - Tamil Nadu State
		<i>Festuca benthamiana</i> Vick.		Australia - South Australia
		<i>Glyceria drumondii</i> (Steudel) C.E. Hubb.		Australia - Western Australia
		<i>Heterachne baileyi</i> C.E.Hubb.		Australia - Queensland
		<i>Homopholis belsonii</i> C.E.Hubb.		Australia - New South Wales, Queensland
		<i>Hubbardia heptaneuron</i> Bor		India - Karnataka State
		<i>Paspalum amphicarpum</i> Ekman		Cuba
		<i>Paspalum jimenezii</i> Chase		Costa Rica
		<i>Plectrachne bromoides</i> (F. Muell.) C.E. Hubb.		Australia - Western Australia
		<i>Poa manii</i> Munroe ex Hillebrand	Mann's bluegrass	United States - Hawaii
		<i>Poa manii</i> Munro		United States - Hawaii
		<i>Streptochaeta angustifolia</i> Soderstrom		Brazil
		<i>Succa sampaiana</i> (A. Hitch.) Soderstrom		Brazil
		<i>Trisetum burnoufii</i> Req. ex Parl.		France - Corsica
		<i>Zea meysii</i> L. ssp. <i>mexicana</i> (Schrad.) Wilkes raza		Mexico
		durango		
Hydatellaceae		<i>Hydatella australis</i> Diels		Australia - Western Australia
		<i>Hydatella leptogyne</i> Diels		Australia - Western Australia
Hydrocharitaceae		<i>Elodea linearis</i> H. St. John	Nashville waterweed	United States - Tennessee
		<i>Elodea schweinitzii</i> (Planchon) Casper	Schweinitz's waterweed	United States - Pennsylvania
Iridaceae		<i>Gladiolus alatus</i> L. var. <i>algoensis</i> Herb.		South Africa - Cape Province
		<i>Hesperantha saldanhae</i> P. Goldblatt		South Africa - Cape Province
		<i>Iris antillanotica</i> Dinsm.		Syria
		<i>Iris damascena</i> Mont.		Syria
		<i>Iris westii</i> Dinsm.		Lebanon
		<i>Moraea incurva</i> Lewis		South Africa - Cape Province
		<i>Romulea papyracea</i> W. Dod		South Africa - Cape Province
		<i>Romulea sulphurea</i> Beguinot		South Africa - Cape Province
		<i>Sisyrinchium farwellii</i> Bickn.	Farwell's blue-eyed-grass	United States - Michigan
		<i>Sisyrinchium hastile</i> Bickn.	spear-like blue-eyed-grass	United States - Michigan
Juncaceae		<i>Juncus griscomii</i>	Griscom's rush	United States - Virginia
		<i>Juncus oronensis</i> Fern.	Maine rush	United States - Maine
		<i>Juncus pervetus</i> Fern.	Barnstable bog rush; old veteran rush	United States - Massachusetts
Liliaceae		<i>Allium rouyi</i> Gaut.		Spain
		<i>Calochortus indecorus</i> Ownbey & M. Peck	Sexton Mt mariposa-lily	United States - Oregon
		<i>Calochortus monanthus</i> Ownbey	Shasta River mariposa; single-flowered mariposa lily	United States - California
		<i>Dipcadi concanense</i> (Dalz.) Baker		India
		<i>Dipcadi reidii</i> Deb & Dasgupta		India
		<i>Ipheion tweedianum</i> (Griseb.) Traub		Argentina
		<i>Lachenalia mathewsii</i> Barker		South Africa - Cape Province
		<i>Smilax leptantha</i> Pennell	catbrier	United States - Georgia
		<i>Tulipa sprengeri</i> Baker		Turkey
		<i>Urginea duthiae</i> Adamson		South Africa - Cape Province
		<i>Urginea ecklonii</i> Baker		South Africa - Cape Province

Table 16.5 Extinct higher plant taxa*

MAJOR GROUP (DIVISION)	FAMILY	TAXON	COMMON NAME	HISTORIC RANGE
	Orchidaceae	<i>Urginea polypyphylla</i> Hook. f.		India
		<i>Acrolophia ustulata</i> Schlechter & Bolus		South Africa - Cape Province
		<i>Caladenia atkinsonii</i> Rodway		Australia - Tasmania
		<i>Caladenia pumila</i> R. Rogers		Australia - Victoria
		<i>Calanthe whiteana</i> King & Pantl.		India - Sikkim State
		<i>Coryciump vestitum</i> Sweet		South Africa - Cape Province
		<i>Diuris fastidiosa</i> R. Rogers		Australia - Victoria
		<i>Paphiopedilum delenatii</i> Guillaumin		Vietnam
		<i>Pleione legenaria</i> Lindley		India - Meghalaya State
		<i>Prasophyllum colemaniae</i> R. Rogers		Australia - Victoria
		<i>Prasophyllum subbisectum</i> Nicholls		Australia - Victoria
		<i>Satyrium gutthriei</i> Bolus		South Africa - Cape Province
		<i>Triphora latifolia</i> G. Luer	nodding cape	United States - Florida
		<i>Zeuxine boninensis</i> Tuy		Japan - Ogasawara-Shoto
	Palmae			
		<i>Acrocomia subinermis</i> Leon ex L.H. Bailey		Cuba
		<i>Corypha taliera</i> Roxb.		India
		<i>Paschalococos dispersa</i> Dransfield		Chile - Easter Island
		<i>Pritchardiopsis jennencyi</i> Becc.		France - New Caledonia
	Pandanaceae			
		<i>Pandanus barklyi</i> Balf. f. var. <i>macrocarpus</i>		Mauritius
		<i>Vaughan & Wiehe</i>		
		<i>Pandanus conglomeratus</i> Balf. f.		Mauritius
		<i>Pandanus iceryi</i> Horne ex Balf. f.		Mauritius
		<i>Pandanus incertus</i> Vaughan & Wiehe		Mauritius
		<i>Pandanus macrostigma</i> Martelli		Mauritius
		<i>Pandanus obsoletus</i> Vaughan & Wiehe		Mauritius
		<i>Pandanus spathulatus</i> Martelle		Mauritius
	Restionaceae			
		<i>Elegia extensa</i> Pillans		South Africa - Cape Province
		<i>Elegia fastigiata</i> Mast.		South Africa - Cape Province
		<i>Leptocarpus ramosissimus</i> Pillans		South Africa - Cape Province
		<i>Lepyrodia heleocharoides</i> Gilg		Australia - Western Australia
		<i>Restio chaunocoleus</i> F. Muell		Australia - Western Australia
	Tecophilaeaceae			
		<i>Tecophilaea cyanocrocus</i> Leybold		Chile
	Zingiberaceae			
		<i>Hedychium marginatum</i> C.B. Clarke		India - Nagaland State

Notes: This list represents information available to WCMC in computerised form as of March 1992. It is intended to include species that are extinct (or presumed extinct) in the wild, whether or not they are in cultivation. Several of these plants, such as *Franklinia alatamaha*, *Paphiopedilum delenatii* and *Tecophilaea cyanocrocus*, are, in fact, well known in the horticultural trade. Others, such as *Encephalartos woodii*, are known only from relatively few specimens, mostly held in botanic gardens. A few others have become extinct in the wild but have been reintroduced from cultivated material grown in botanic gardens.

The information available is strongly biased geographically: many other species of higher plants have undoubtedly become extinct but lack of country-based data prevents their inclusion here. Some of the species in this list are almost certainly still extant in remote, isolated areas; publication of this list should stimulate searching for them.

* Includes some taxa below species level.

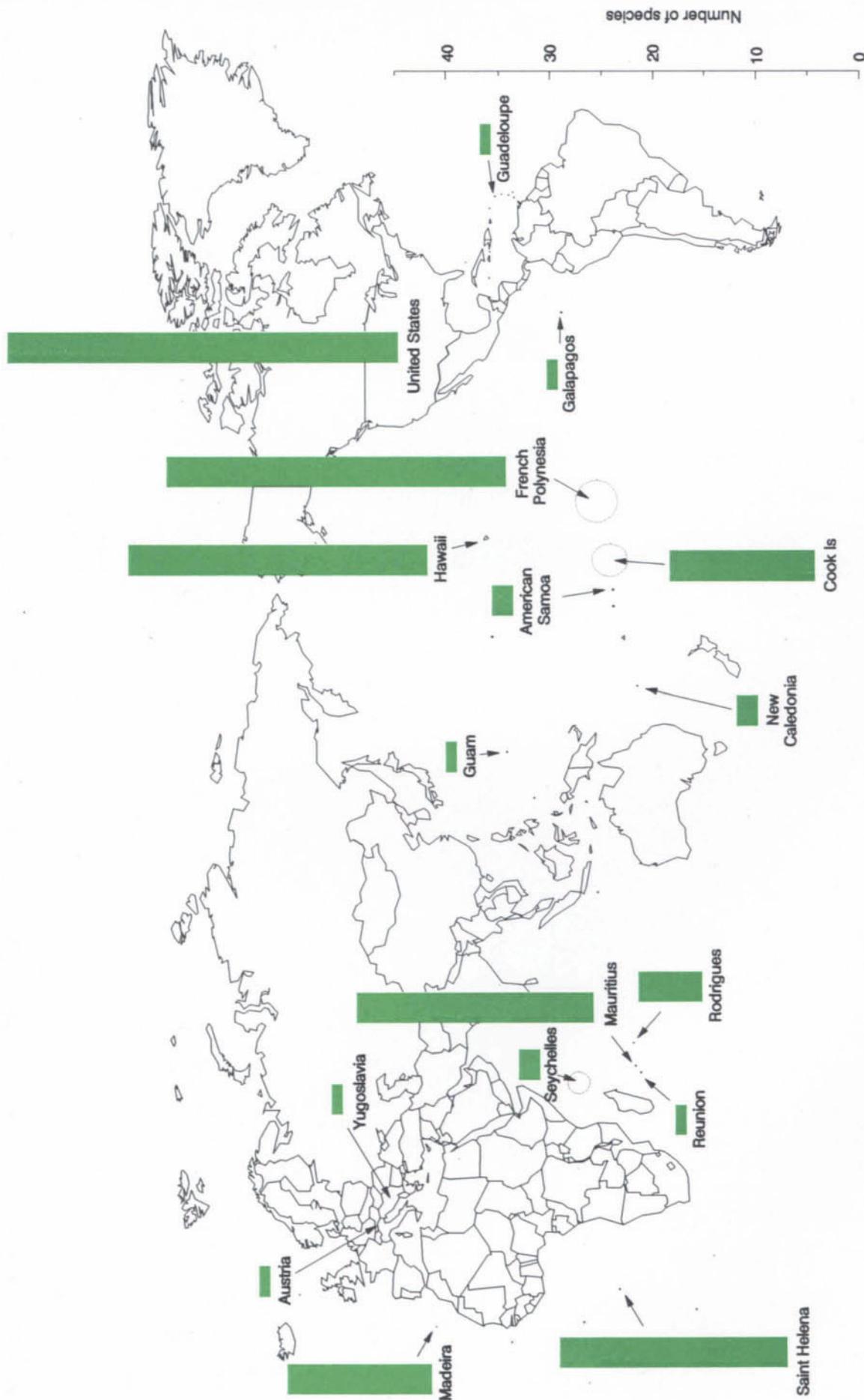
Notes for Table 16.6, overleaf: (1) Two amphibians (USA and Israel), one coral (Panama) and one mammal (Caribbean) are not included in this table. (2) The above species may have lived in more than one country therefore total numbers do not necessarily agree with other tables. * indicates islands which are not on the standard country list. They have been included separately because of the importance of islands when considering extinctions.

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Table 16.6 Known animal extinctions since c. 1600 by country

	MOLLUSCS	INSECTS	FISHES	REPTILES	BIRDS	MAMMALS	TOTAL
ASIA							
India					3		3
Indonesia					2		2
Nansei-shoto (Japan)*					2		2
Nepal					1		1
Ogasawara-shoto (Japan)*					3		3
Philippines					1	3	4
Taiwan		1					1
Thailand						1	1
'USSR'							
Bering Straits ('USSR')*					1	1	1
EUROPE							
Austria	1						1
Canary Islands (Spain)*					1		1
Corsica (France)*						1	1
Faeroe Islands					1		1
Germany		1				1	2
Iceland					1		1
Sardinia (Italy)*						1	1
United Kingdom					1		1
Yugoslavia	1						1
NORTH & CENTRAL AMERICA							
Bahamas					1		1
Barbados				1		1	2
Canada			2		2		4
Cayman Is					1	3	4
Cuba					1	4	5
Dominican Rep						6	6
Greenland					1		1
Guadalupe (Mexico)*					2		2
Guadeloupe	1			1			2
Guatemala					1		1
Haiti						6	6
Jamaica			2		1		3
Little Swan Island (Honduras)*						1	1
Martinique			3			1	4
Mexico			12		1	2	15
Navassa Island (USA)*				1			1
Saint Lucia						1	1
Saint Vincent and the Grenadines						1	1
United States	38	9	17		4		68
Virgin Islands (US)				1			1
SOUTH AMERICA							
Brazil					1		1
Colombia					1		1
Galapagos (Ecuador)*	1					4	5
Uruguay					1		1
OCEANIA							
American Samoa	2						2
Australia				1		17	18
Bougainville (PNG)*					1		1
Chatham Island (NZ)*		1			3		4
Christmas Island (Australia)*						2	2
Cook Islands	14				1		15
Fiji		1					1
French Polynesia	33				5		38
Guam	1				1		3
Hawaii (USA)*	29	42			15		86
Kangaroo Island (Australia)*					1		1
Lord Howe Island (Australia)*		1			2		3
Micronesia, Federated States of					3		3
New Caledonia	2				3		5
New Zealand		1	1	1	10	1	14
Norfolk Island (Australia)*					1		1
Palau						1	1
Phillip Island (Australia)*					1		1
Solomon Islands					1		1
Stephens Island (NZ)*		1			1		2
Tasmania (Australia)*						1	1
Wake Island (USA)*					1		1
Western Samoa					1		1
ANTARCTICA							
Falkland Islands (Malvinas) & dependencies						1	1
AFRICA							
Algeria						1	1
Ascension Island (UK)*					1		1
Cape Verde				1			1
Madagascar					3		3
Madeira (Portugal)*	14						14
Mauritius	23	1		5	11	1	41
Réunion	1			2	11	1	15
Rodrigues (Mauritius)*	6			4	11		21
Saint Helena	22	2					24
Seychelles	2				1		3
South Africa						2	2
Tristan da Cunha (UK)*					1		1

Figure 16.6 Known animal extinctions since c. 1600: Molluscs



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Figure 16.7 Known animal extinctions since c. 1600: Arthropods

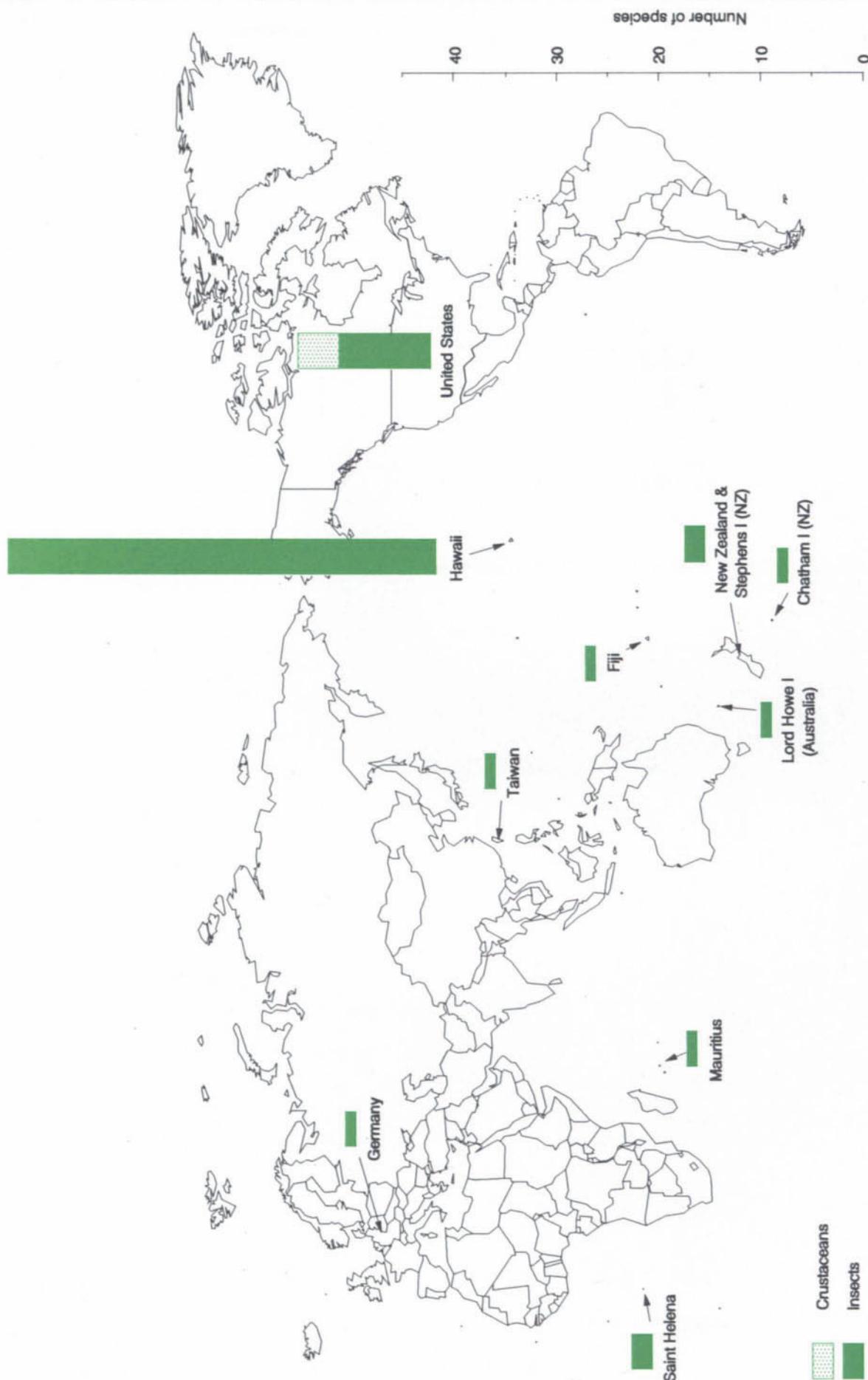


Figure 16.8 Known animal extinctions since c. 1600: Fishes, reptiles and amphibians



Figure 16.9 Known animal extinctions since c. 1600: Birds

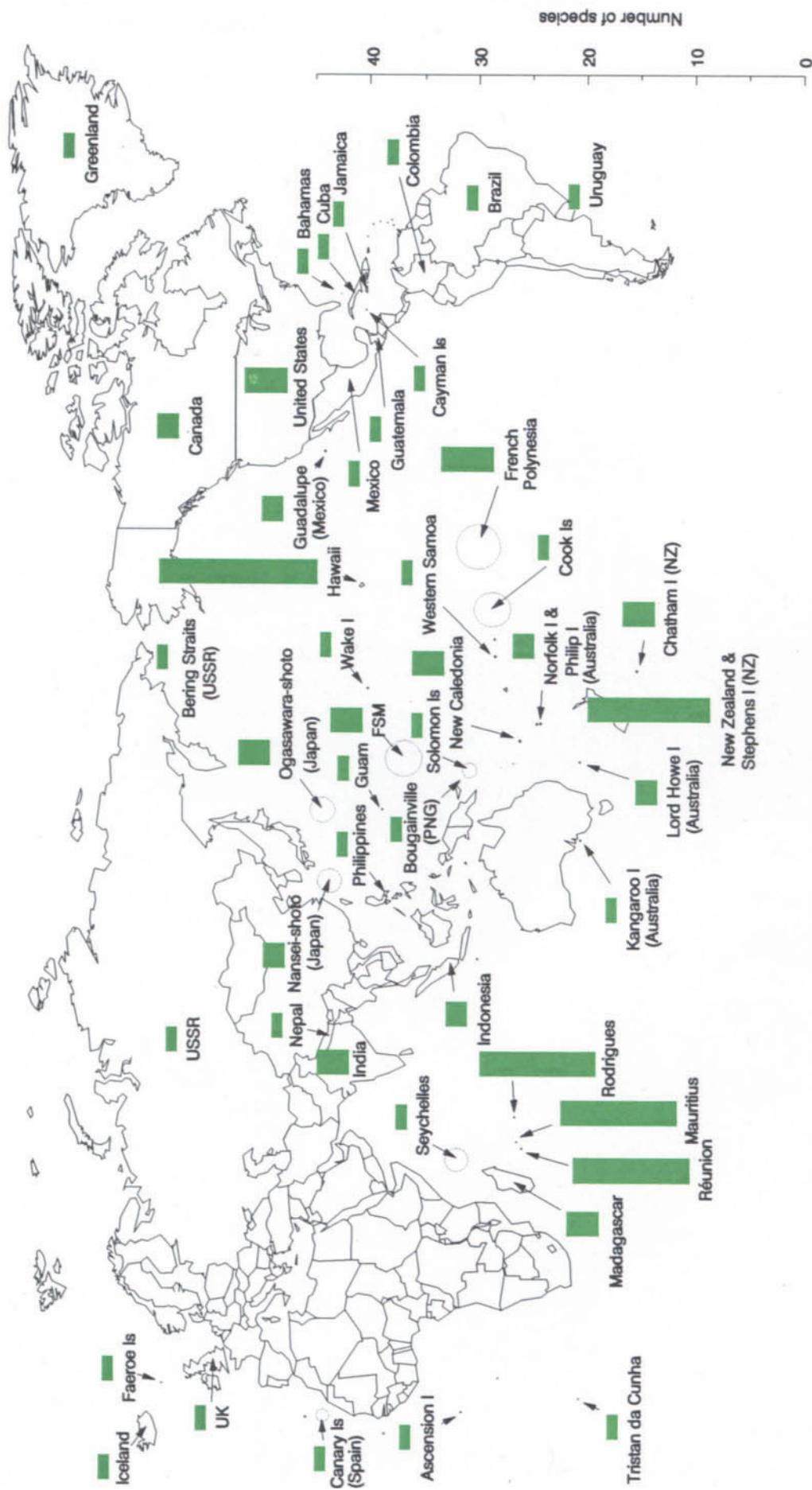
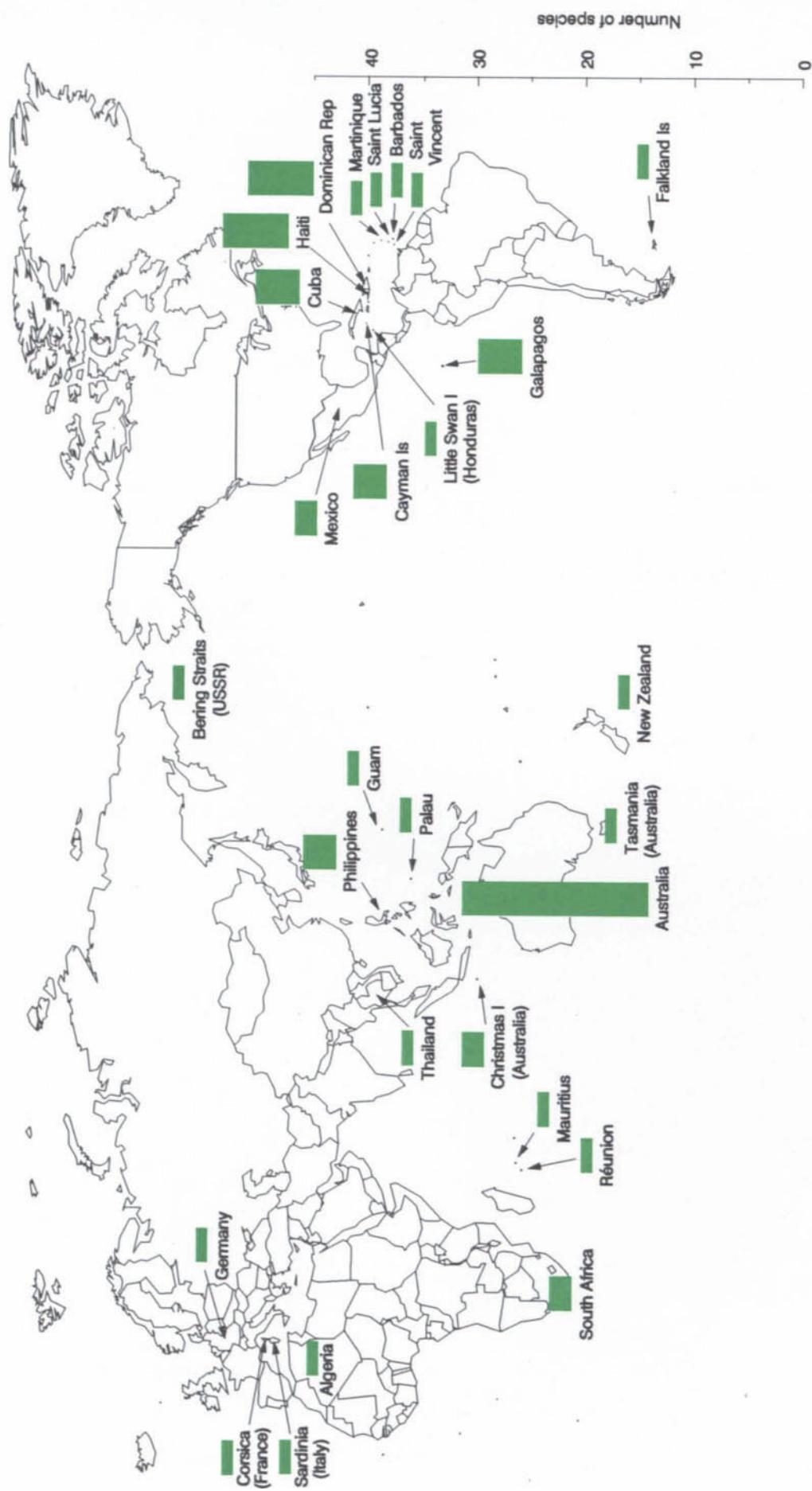


Figure 16.10 Known animal extinctions since c. 1600: Mammals



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Table 16.7 Animal species surviving only in captivity

SPECIES	ENGLISH NAME	NOTES
MOLLUSCS		
Order STYLOMMAТОPHORA		
Family Partulidae		
<i>Partula</i> spp.	Viviparous Tree Snails	French Polynesia. Exterminated in wild after introduction of <i>Euglandina rosea</i> in 1977. Various captive colonies around the world. Population status information as at March 1991 *.
<i>Partula affinis</i>		Tahiti. Functionally extinct, only 1 left alive.
<i>Partula aurantia</i>		Moorea. Functionally extinct, only 1 left alive.
<i>Partula clara</i>		Tahiti. Critical.
<i>Partula hyalina</i>		Tahiti. Increasing.
<i>Partula mirabilis</i>		Moorea. Critical.
<i>Partula mooreana</i>		Moorea. Seriously declining.
<i>Partula nodosa</i>		Tahiti. Increasing.
<i>Partula otaheitana</i>		Tahiti. Increasing but low numbers.
<i>Partula suturalis</i>		Moorea. Declining/stable.
<i>Partula taeniata</i>		Moorea. Increasing, good numbers.
<i>Partula tohiveana</i>		Moorea. Increasing but all from 4 individuals.
FISHES		
Order CYPRINODONTIFORMES		
Family Cyprinodontidae **		
<i>Cyprinodon alvarezi</i>		Mexico. Last specimens removed from wild February 1992.
<i>Megupsilon aporus</i>		Mexico. Last specimens removed from wild February 1992; a number of captive populations exist.
Family Poeciliidae		
<i>Xiphophorus couchianus</i>	Monterrey Platfish	Mexico. Extinct in the wild in 1960s; three captive populations.
Family Goodeidae		
<i>Skiffia francesae</i>	Golden Sawfin	Mexico; widespread in captivity.
BIRDS		
Order CICONIIFORMES		
Family Ciconiidae		
<i>Gymnogyps californianus</i>	Californian Condor	USA. Last individual taken from wild 1987. 52 in captivity at end of 1991.
Family Columbidae		
<i>Zenaida graysoni</i>	Socorro Dove	Socorro I (Mexico). Extinct post-1958. Large captive populations.
MAMMALS		
Order PERISSODACTyla		
Family Equidae		
<i>Equus ferus</i>	Wild Horse	China, Mongolia. Some disagreement on taxonomic status. <i>E. ferus gmelini</i> , the Tarpan, exterminated late 19th century. <i>E. f. przewalskii</i> , Przewalski's Horse survives in zoos, last seen in wild in 1968.
Order ARTIODACTyla		
Family Bovidae		
<i>Bos taurus</i>	Domestic cattle	Europe, North Africa and the Near East. The Aurochs <i>B. t. primigenius</i> , the wild ancestor was exterminated in 1627.

Notes: * Reference: Partula '91, Proceedings of the Partula Propagation Group Meeting, 16 May 1991. Compiled by S. Tonge, JWPT. ** Note two further *Cyprinodon* species, Charco Azul and Charco Palma will probably also soon be extirped in the wild (P. Loiselle, pers. comm.).

Table 16.8 Animal species extirpated in wild and reintroduced**BIRDS****Order GRUIFORMES**

Family Rallidae

Rallus owstoni

Guam Rail

Guam (USA). Extinct in wild 1985.
Reintroduced 1990/91.**MAMMALS****Order CARNIVORA**

Family Mustelidae

Mustela nigripes

Black-footed Ferret

USA. Last specimen taken from wild in 1987.
Reintroduced 1990/91.

Family Canidae

Canis rufus

Red Wolf

USA. Extinct in wild 1980, reintroduced late
1980s.**Order ARTIODACTYLA**

Family Bovidae

Bison bonasus

Wisent

Europe. Exterminated in wild by 1927.
Reintroduced to several locations.*Oryx leucoryx*

Arabian Oryx

Middle East. Last recorded in the wild in 1972.
Reintroduced in Oman in 1982.

Family Cervidae

Elaphurus davidianus

Père David's Deer

Discovered in captivity in 1861. Now exists in
zoos worldwide. Reintroduced to China.