The difficulty here is that we cannot look at ancient mantle directly (since we have no samples of it); we must instead reconstruct the state of early mantle depletion from volcanic rocks, usually basalts, that were created by the melting of this mantle.

Although it is nearly impossible to infer the absolute concentrations of trace elements in a mantle region from the concentrations in the basalts formed in that region, it is comparatively easy to determine the concentration ratios of such elements in the melting region from the ratios measured in the basalts. The Nb/U ratio is particularly useful in this respect because its value has been changed from an original Nb/U = 30 in the mantle before continent formation (inferred from analyses of stony meteorites) to a value of Nb/U = 47 in the present-day mantle (3). This change is clearly related (and complementary) to the formation of the continental crust, which has a value of Nb/U = 10 (see figure).

Sylvester *et al.* (1) have used this "diagnostic" ratio to show that basaltic rocks from a 2.7-billion-year-old region of Western Australia were derived from a mantle source with a Nb/U ratio (= 47) that is indistinguishable from that of modern mantle rocks. The only previous attempt to study the Archean mantle in this fashion yielded rather ambiguous results, seemingly indicating that the mantle at that time had an Nb/U ratio closer to the value of the undifferentiated Earth (4). In that study, a wide variety of ancient volcanic rocks from various localities had been analyzed. Sylvester *et al.* adopted a different strategy and decided to do a very systematic study of a single formation. They found that the apparently scattered results were caused by small but variable amounts of contamination of the lavas by crustal rocks, which would tend to lower the Nb/U ratios and bring some of them close to the "primitive" value of Nb/U = 30. Nevertheless, their least contaminated samples have Nb/U ratios that are indistinguishable from the value (47) of the modern mantle, which provides a strong argument that 2.7 billion years ago, a similar amount of continental crust existed as today.

Several important issues remain to be resolved. One of these concerns the volume of the mantle reservoir that has been sampled. One formation from Western Australia cannot constrain the Nb/U ratio of the entire mantle. Similar studies need to be done on other continents to confirm the inference that a general characteristic of the ancient mantle has been measured. Another issue concerns the relatively "young" age of the formation studied. The period around 2.7 billion years ago constitutes the end, not the beginning, of the so-called Archean period of Earth history. This time was marked by a particularly high rate of continental growth. At least, this is what numerous workers who have studied the ages and composition of Precambrian terrains on several continents (5) have concluded. Thus, even if the continental crust grew irreversibly from small beginnings about 4 billion years ago, it may have grown to more than half of its present mass by 2.7 billion years ago, and the complementary imprint on the trace element ratios of the residual mantle should have been already quite significant, although not as great as at present. This uncertainty means that similar studies must be done in even more ancient terrains and on different continents before the results of Sylvester *et al.* will be accepted as a general constraint on the evolution of the terrestrial continental mass. Nevertheless, a crack has been made in one of the more intractable problems of understanding the history of the ground we live on.

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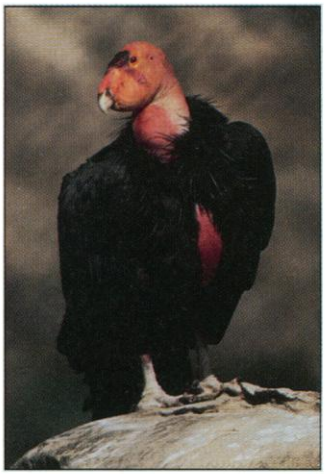
ECOLOGY

Science and the Protection of Endangered Species

H. Ronald Pulliam and Bruce Babbitt

Not all species are equally susceptible to extinction, and some species may actually benefit from land use and other changes caused by human activity. To accommodate both sustainable economic development and the protection of biological diversity, we need to know what kinds of species are most vulnerable and what kinds of human activities most threaten them.

On page 550 of this issue, Dobson *et al.* (1) demonstrate that "hot spots" for endangered species tend to occur where the ranges of many endemic species overlap with intensive urbanization and agriculture. Endemic species have, by definition, a restricted geographic distribution. As the size of the geographical area that a species occupies decreases, its local density in the occupied area also decreases (2). As Dobson *et al.* confirm, endemics are prone to extinction, especially in the face of rapid habitat loss or degradation.



California condor. An endangered species recently successfully reintroduced into its former range in Arizona.

Hawaii, Florida, and California have both the most endemic species and the most endangered species. The high number of Hawaiian endemics is a result of the small size of the islands and their extreme isolation. The Lake Wales Ridge and adjacent areas of central Florida are exceptionally rich in endemic plants, arthropods, and vertebrates. During much of the past 10 million years, coastal Florida has been submerged, isolating the higher ridges and providing ample opportunities for speciation. In California, it is the coastal Mediterranean climate and unusual habitat features—such as isolated patches of serpentine soils—that have resulted in high endemism. All three of these areas, especially California, Florida, and the Hawaiian island of Oahu, are experiencing exceptionally rapid population growth and economic development. In Florida, for example, the ridge tops that harbor so many endemic species also provide the right microclimatic conditions for citrus production, and large tracts have been converted from relatively natural vegetation to agricultural production in the past 20 years.

Urbanization and agriculture are not the only causes of the decline of native flora and fauna in the United States. Many recent ex-

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tinctions and population declines in Hawaii, for example, have been caused by the introduction of exotic species. Throughout the United States, impoundments, river dredging, and other riverine development projects combined with the introduction of exotic species like the sea lamprey (*Petromyzon marinus*), the grass carp (*Ctenopharyngodon idella*), the Asian clam (*Corbicula fluminea*), and the zebra mussel (*Dreissena polymorpha*) may be responsible for the endangerment of hundreds of fish, mollusks, and other aquatic species.

Although many species continue to decline in number and some are threatened with extinction, the news about endangered species is not all bad. Some species have recovered and have been removed from the endangered species list or "downgraded" from endangered to threatened status, and others are well on their way to recovery. Continued progress toward recovery will require the application of good science to natural resource policy and management decisions.

Sound scientific information about the status and trends of biological resources and reliable information about the causes of species endangerment must be the foundation of our efforts to conserve biological diversity. The recovery of the bald eagle (*Haliaeetus leucocephalus*), leading to its recent downgrading from endangered to threatened status, would not have been possible without scientific documentation of the effects of dichlorodiphenyltrichloroethane (DDT) on its reproduction and the subsequent banning of that pesticide nationwide. In a growing number of cases, ranging from the burrowing owl (*Athene cunicularia*) in California to pitcher plants (*Sarracenia* spp.) in Alabama, better scientific information about the habitat requirements of species has led to cooperative management plans involving state, federal, and private partners that provide hope for the recovery of endangered species with relatively little negative impact on economic activities.

In addition to knowing more about the specific factors responsible for the decline of individual species, we need to expand our general understanding of what kinds of species are prone to extinction and incorporate this information into proactive, multiple species protection plans. Dobson *et al.* discuss the vulnerability of endemic species, but are all geographically restricted species necessarily at greater risk? For example, biogeographers often distinguish between paleoendemics, which are relict species left by the extinction of their close relatives, and neoendemics, which are newly evolved taxa often restricted to a small area (*3*). Are neoendemics rare only by virtue of their recent emergence and, therefore, less likely to go extinct than paleoendemics? Or does the very longevity of paleoendemics suggest that they are less likely to go extinct in the future because of their success in the past?

We must also improve our understanding of what human activities are most harmful to species and under what circumstances organisms can tolerate or even benefit from human activities. Species that do well in early successional habitats—such as the endangered Kirtland's warbler (*Dendroica kirtlandii*) in the jack-pine forests of Michigan and Bachman's sparrow (*Aimophila aestivalis*) in southeastern pine forests—sometimes benefit from both controlled fire and limited clear-cutting when these activities create appropriate forest openings. Many early successional species are adapted to living in a mosaic of shifting habitat patches. Can we use our growing knowledge of metapopulation dynamics to devise forest management plans that allow for both the viability of native plant and animal populations and profitable forest harvest (*4*)?

And finally, how can we use our general knowledge of the distribution of rare and threatened species to maximize the protection of species at the least cost and inconvenience to the public? As Dobson *et al.* point out, many threatened and endangered species are aggregated in relatively small areas, and "a large proportion of endangered species can be protected on a small proportion of land." If we improve our knowledge of the distribution and co-occurrence of species, then we can provide a sounder scientific basis for ecosystem-based habitat conservation plans (HCPs), cooperative agreements that protect many species under a single plan. When properly designed, on the basis of a thorough understanding of species distribution and habitat requirements, and implemented with the cooperation of local authorities and landowners, such plans provide protection for currently endangered species. Also, by providing habitat protection for many other species, HCPs provide a proactive mechanism for preventing the future endangerment of additional species.

An enhanced version of this Perspective, with live links, can be seen in *Science* Online on the Web at http://www.sciencemag.org/

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TRANSLATION

eIF4G: A Multipurpose Ribosome Adapter?

Matthias W. Hentze

To be joined as partners in protein synthesis, mRNAs and ribosomes must be presented to each other in the ritual of translation initiation. Protein-mRNA interactions precede the engagement of the small ribosomal subunit (40S) with the mRNA. This rate-limiting step is followed by the joining of the large (60S) subunit at the translation initiation codon of the mRNA and the beginning of protein synthesis (*1*). Recent data from several laboratories have implicated a long-known translation initiation factor—eIF4G (formerly p220 or eIF-4γ)—as a critical link between mRNAs and 40S subunits during the initial engagement process.

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Cellular mRNAs receive a 5′ cap structure (^{7}mGpppN) and a 3′ polyadenylated [poly(A)$^+$] tail as a nuclear dowry before their export into the cytoplasm as mature mRNAs. Both these moieties activate translation initiation in concert with cytoplasmic binding proteins, the cap-binding protein eIF4E, and the poly(A)$^+$ binding protein (Pab1p in yeast). However, some picornaviral RNAs and a few cellular mRNAs have specialized sequences within their 5′ untranslated regions that directly promote ribosome binding independent of a cap structure. These are the internal ribosome entry sequences (IRES) (*2*). How can all these different modes of connecting mRNAs and 40S ribosomal subunits be used for translation initiation? The cell's answer may resemble the solution found by avid international travelers for the difficulties of using electrical appliances in foreign