Hidden Complexities in the Risks of Extinction

A combination of theoretical and empirical data reveals that extinction is more complex than often appreciated, a discovery with practical consequences

CONSERVATION BIOLOGISTS increasingly are faced with taking drastic actions in order to save threatened species, and this often involves manipulating habitats in ways that once were uncountenanced by the ecologically pure in heart. For instance, University of Tennessee ecologist Stuart Pimm is currently discussing a proposal to restore the devastated bird population of the island of Guam in the West Pacific. The idea is to return to a nearby island populations of the only two species that were rescued from Guam. As always, says Pimm, "we have to answer the question of the minimum number of individuals that can be introduced in any particular location."

Ideally, of course, one would use a large number of individuals in such a program, thus achieving some kind of insurance policy against potential disaster. But, for obvious reasons, that option is often not available. "In any case," Pimm told *Science*, "if you had 100 individuals, you would want to know whether it would be better to introduce them all into one locality, or, for instance, put populations of 10 in 10 different localities."

The answers to questions of this sort depend on the fact that populations are prey to two types of danger, either of which can result in extinction: these are demographic accidents (vagaries of birth and death schedules and of sex-ratio fluctuations) and environmental fluctuations. Biologists have thought about these issues a great deal, both with theoretical modeling and empirical field studies, and, in addition to the obvious notion that large populations are safer than small ones, one message emerges clearly: small species are less vulnerable to extinction than large species.

For the Guam project, and for other potential reintroductions, Pimm needed the equation in more detail. He therefore teamed up with Jared Diamond and H. Lee Jones, of the University of California, Los Angeles, and did a theoretical and empirical analysis of various factors that affect population extinction. In addition to population size and body size, these factors included longevity, potential rate of population increase, and inherent population size fluctuation over time.

Pimm and his colleagues obtained useful—and somewhat surprising—guidance on the minimum population size for successful reintroduction, and also achieved a greater insight into the extinction process in general. They report that "the effect of body size on extinction rate is both more interesting and more complex than previously recognized."

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In an earlier analysis of population data of 100 bird species in 355 populations on 16 islands around Britain, Diamond showed that "the effect of population size on extinction rate was overwhelming." No surprise here. What was interesting, however, was that for a given population size, extinction rate varied considerably between species. In the latest paper Diamond, with Pimm and Jones, asks, "Is such variability merely noise, or does it reflect predictable differences between species?"

The literature on extinction theory yields three principal factors that might affect extinction rates between species. Extinction rates should be lower for species with (1) high rates of potential population increase (r); (2) high longevity; and (3) shallow fluctuation in population density through time. As Pimm and his colleague note, "The difficulty is that all three parameters are linked." Simple equations are therefore not readily derived from them.

For instance, from the smallest to the largest of creatures, there is a dramatic decrease in the potential rate of population increase, and this is accompanied by an equally dramatic increase in longevity. So, large-bodied species will have low r and high longevity, factors that have opposite effects on vulnerability to extinction. For instance, having a low r reduces a population's ability to bounce back quickly following environmental accident. Great longevity, by contrast, means that year by year a population is less vulnerable to demographic problems.

Pimm and his colleagues therefore needed to know the net effect of these opposite influences on extinction. Their theoretical analysis (later confirmed by empirical data on the British birds) predicted that in small populations, where demographic factors predominate, small-bodied species will be at greater risk from extinction than large species. Conversely, in large populations, where environmental factors predominate, the reverse will be true: large-bodied species will be at greater risk from extinction than small species.

Of key importance here is the population size at which these two vulnerabilities to extinction match and cross over, for this gives an indication of the minimum population size for establishing new populations. From theoretical calculation, that number was five pairs and from analysis of the British bird data, seven: good correlation, but both remarkably small.

"Conservation biologists tend to write off as hopeless those species numbering only 7 pairs and to concentrate on saving endangered species reduced to 20—500 pairs, for which there is more hope," note Pimm and his colleagues. "Since our 'crossover population size' . . . is only 7 pairs, readers may initially view that discovery of a crossover population size as of only academic interest. In fact, such small populations are of practical conservationist concern in numerous situations."

For instance, the habitats of many endangered species are often highly fragmented, "forcing one to consider the viability of many isolated small subpopulations rather than of one contiguous large population." And, as noted earlier, it may well be more effective in reintroduction programs to seed many areas with small populations rather than concentrate all individuals in one large population.

This study has shown how different biological parameters are often closely related to each other, and therefore sometimes produce surprising results. Ideas about the effect of body size on extinction seem to have fallen prey to this. "Undoubtedly the main reason why large animals [are often considered] to be prone to extinction is that large animals tend to have lower population sizes." ■ ROGER LEWIN

ADDITIONAL READING

S. L. Pimm *et al.*, "On the risk of extinction," *Am. Nat.* **132**, 757 (1989).