Wilson, *The Diversity of Life*, a book report

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Entomologist and sociobiologist E. O. Wilson (1929—) works up slowly to the point of his book of popular non-fiction, *The Diversity of Life* [Wilson92], almost as if it were a rare formicid spotted in the wild. His objective for the book is to raise the alarm of impending anthropogenic species extinctions on a catastrophic scale, perhaps as severe as the five mass extinctions known from the fossil record. Even though late twentieth century biology has not fully estimated the number of species on the planet, let alone computed the current rate of extinction, "*in the small minority of groups of plants and animals that are well known, extinction is proceeding at a rapid rate, far above prehuman levels. In many cases the level is calamitous: the entire group is threatened.*" (p. 255, emphasis in original)

Making Connections

But in order to get us, his readers, to that place, he covers a lot of preliminary ground. He has at least two reasons for doing so: First, to a researcher of his experience and intellect, everything concerning the web of life is connected. In order to discuss the adaptive radiation of honeycreepers on the Hawaiian archipelago, he must explain the various mechanisms of genetic mutation and the ways that sympatric species maintain reproductive isolation, and so on back to the biological definition of a species.

Furthermore, he does not miss the opportunity to mention briefly a few of his lifelong research concerns, be they ever so removed from the main subject of the book. These include the success of eusocial insects like the ants (chapter 1), about which he has written since the 1970s, and the implications for human societies[1] [Wilson71, Wilson00, Wilson03, Wilson04] as well as our sensed connection to the natural world that he captures in the term "biophilia" [Wilson84]. A closely related idea is that of wilderness, about which he writes in the closing chapter, it "settles peace on the soul because it needs no help; it is beyond human contrivance." (p. 350)

The second rhetorical tactic that Wilson employs is to sweeten his bitter message of imminent disaster with a survey of nature's resplendent variety. Hence he:

- details the far-reaching economic benefits of obscure and threatened organisms, from maize genes that confer perennial growth, to a cancer remedy derived from a snail species;
- considers the structure of a millimeter-thick microbial mat, layered into shade-tolerant sulfide oxidizers and a canopy of *Spirulina*;
- samples the variation in flower and fruit, beetle and crab, to be found in the world, in a lush section of color photographs.

[1] Just as his work in the 1970s made waves, Wilson continues to make vigorous contributions to the study of the biological basis of altruism, which is key to eusociality. His recent paper with Martin Nowak and Corina Tarnita [Nowak10] is summarized in the general media [French11, Lehrer12].

The sequence of images by Mark W. Moffett of the "microwilderness" in a decaying acorn is especially impressive. And so Wilson chooses a title for this book that deflects from the gloomsaying final chapters, and rather one that accentuates the positive and celebrates diversity. On the whole, the book shows his fundamental optimism that the decline in species numbers can be curbed [French11].

The Measure of Extinctions

At the time of the book's writing, estimates of worldwide species numbers were uncertain, with a range of at least one order of magnitude. What was worse, the rate of species loss, as a proportion of the "background" extinction rate of 1 species per million per year, was even less well understood. So Wilson sets out to estimate that rate, by computing the rate of species loss in the tropical rain forest due to deforestation, and then audaciously extrapolating to all species, all habitats, planet-wide.

To estimate rain forest species loss rates, he uses results from his research with Robert MacArthur [MacArthur67] into the biogeography of isolated habitats where new species colonize and existing species die out at particular rates. This field work and analysis established a relationship between the number of species, *S*, to be found on an island, and the island's area, *A*:

$$S = CA^z$$

where *C* is a scaling constant and *z* is a parameter. It has been measured at about 0.15 for birds and 0.35 for less mobile species; as a convenience, a *z* value of $\log_{10} 2$ (approximately 0.30) is a good approximation. Wilson's clever stroke is to consider as islands the patches of forest that remain as the country is converted to farm, and to use $S = CA^z$ to reckon the number of species lost as the patches shrink. Once some conservative assumptions are made and the numbers crunched, Wilson's worldwide extinction rate is 0.27% annually, more than a thousand times greater than the baseline rate.

As a patch shrinks and the local population of a species shrinks with it, what tips the local population into extirpation? A reduced population means the opportunity for unfavorable genes to be expressed, in a phenomenon called inbreeding depression, leading to lowered genetic variation and increased reproductive failure. Wilson and others' work suggests that an effective population even as large as 50 can experience inbreeding depression; with fewer than that, the dice game of genetics means inevitable death of the population [Dobson96]. Furthermore, a population of 500 breeding individuals, ten times more, is needed for long-term survival. However, Wilson closes this section with a caution: "For species passing through the narrows of small population size, the Scylla of demographic accident [irregular, drastic reductions caused by environment change] is more dangerous than the Charybdis of inbreeding depression." (p. 238)

Case Histories

An effective book for the general reader depends on vivid examples and case histories, and Wilson chooses his well.

- The Sea Otter (*Enhydra lutris*) exemplifies the keystone species concept; overhunting of this mammal started a tropic chain of events that reduced the kelp forest and the organisms that depend on it.
- Experimental manipulation of patch size by Thomas Lovejoy demonstrated a cascade of second-, third-, and higher-order effects: as large mammals deserted the smallest study plots, dung-dependent beetles declined and temporary pools vanished, and hence *Phyllomedusa* frogs disappeared.
- A massive destruction of cloud forest habitat Centinela Ridge in Ecuador destroyed 90 endemics and other unique forms, prompting Wilson to coin the term "centinelan extinction."
- The complex relationship between a mosquito, *Aedes sierrensis*, and *Lambornella clarki*, a protozoan that is by turns prey and parasite of the larval mosquito underscores Wilson's point that ecosystems must be analyzed bottom-up, not top-down.

Economics and Policy

Wilson's case for the benefits of preserving habitat and its dwellers is based on (a) a catalog of economic gains to be had from obscure and/or underexploited species (for example, an East African hibiscus as a pulp source whose fibers can be whitened with "only minor chemical treatment") and (b) the still-developing concept of ecosystem services. His emphasis on sustainable development and "biological wealth" suggests the pragmatism of Gifford Pinchot; on the other hand, he sometimes takes a hard line, as when he passes over cost-benefit analysis in favor of SMS (Safe Minimum Standard) guidelines, which treat each species "as an irreplaceable resource for humanity, to be preserved for posterity unless the costs are unbearably high." (p. 310) He is sunny about the prospects of what we now call GMOs, quoting Thomas Eisner's metaphor of a species as a loose-leaf book. *Ex situ* conservation in the form of seed banks and cryotoria will never be sufficient, as they neglect pollinators and symbionts; rather, a doubling of the land surface dedicated to reserves is needed.

The volume is a fine introduction to the concepts of ecology and evolutionary biology. The general reader specifically interested in the nature and preservation of diversity might prefer a work like Dobson's [Dobson96].

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