Creating the Nation's first BioPark
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Letter From the Desk of David Challinor
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"Biodiversity" has become a household word and is used to emphasize the importance of such species-rich ecosystems as tropical rain forests and coral reefs. Having wide species diversity is touted as a desirable condition, in contrast to few-species ecosystems, such as the plant monocultures in large commercial farms or tree plantations. The latter are vulnerable to diseases, insect buildups and soil nutrient deficiencies and can often be maintained only by the application of fertilizers, herbicides and insecticides. Such treatment is necessary to reduce competition from unwanted plants and insects and may have long-term deleterious effects on the environment. Unfortunately, the benefits and costs of biodiversity are not easy to quantify and some scientists are now attempting to measure biodiversity's relative importance.

This letter will report on some results achieved in measuring biological productivity as one way to determine the value of biodiversity. A future letter may discuss the benefits and costs of cultural diversity -- a topic that is likely to generate more heat than a discussion of plant and animal diversity.

Last March in California the Global Biodiversity Assessment Synthesis Conference considered the question: How much biodiversity can an ecosystem afford to lose and still retain its productivity? Scientists have long exhorted policy makers to preserve biodiversity, and the policy makers in turn asked the scientists to demonstrate the importance of biodiversity. This has not been easy, because there are two principal approaches to measuring ecosystem productivity. One way is to measure the movement of energy through a forest or coral reef, for example, without concentrating on individual groups of animals or plants. Another approach, used by population biologists, is to study the food webs of species without emphasizing their roles in the total energy cycle.

The conclusions of this meeting were summarized in *SCIENCE*, 8 April 1994, 264: 202-3. For nutrient cycling and decomposition species, diversity has little direct effect on total productivity, but systems with greater plant diversity were seemingly able to convert carbon dioxide and water into plant material more abundantly than systems with less diversity. However, diverse systems, with a cushion of "extra" species, can tolerate the loss of some plant species without sustaining a drop in productivity. Thus some plants and animals appear to be more essential for productivity (as measured by scientists) than others. Isolating such key species may be insurmountable, but with policy makers clamoring for answers, ecosystem ecologists are now testing two hypotheses on the importance of biodiversity that seem at odds with each other.

The first theory was presented in 1981 by two distinguished ecologists, Paul and Anne Ehrlich. They used the analogy of rivets on an airplane, whereby the plane is the ecosystem and the rivets are the myriad species holding it together. The loss of one rivet will weaken the plane imperceptibly, but after a certain threshold of rivet loss is exceeded, the plane would crash.

About ten years later another theory was put forth by Brian Walker, an Australian ecologist. He postulated that a large majority of species was not really needed to maintain an ecosystem; only a few crucial ones kept it going. This was called the redundancy hypothesis.

An experiment to test the Ehrlichs' "rivet" theory was performed in England in which 14 artificial ecosystems were grown in a climate-controlled greenhouse. Each of the 14 contained the same total number of plants, but the varieties of annuals planted were either of 2, 5 or 16 different species groups. The richest species groups produced the greatest mass of plant matter. The experiment was repeated on an even larger scale and the results supported the original trial, thereby supporting the value of diversity. Further outdoor experiments have shown that meadows in Minnesota with a high degree of plant diversity recover from stress such as a drought faster and more completely than meadows with fewer species. Such experiments support the value of biodiversity to increase production and to recover more rapidly from stress, but leave still unanswered how many species in an ecosystem may be redundant.

In both experimental and natural ecosystems there is evidently a point at which increased biodiversity no longer causes a significant growth in productivity. Temperate forests, for example, seem to have more tree species than they need for maximum production. Thus in the northern hemisphere, East Asian forests have 876 tree and shrub species, followed by North American with 158, and European forests with only 106. Yet all three forest systems show about the same productivity. In theory, loss of some redundant species will not automatically cut productivity of an ecosystem.

If this supposition is true, do we humans really need to worry about loss of biodiversity? I believe we do, because nature is conservative and tends to have back-up systems. As evolution progresses, new varieties and species continually develop. Some succeed and some fail. Random extinctions have occurred ever since life began, but a plethora of species, although hard to maintain in complex ecosystems, provide a base to handle unexpected stress and change such as droughts, fires and floods. Human-caused extirpation of species, however, is not random and therein lies the danger to the planet. Clearing a new world tropical forest for pasture land replaces the myriad species of plants and animals that evolved to live in that complex forest, with one or two species of grass (often exotic ones) to be eaten by alien livestock. On a small scale we have converted sections of Arizona deserts to expensively maintained golf swards dependent on a finite fossil water source. Ski slopes cut through montane forests, and drained wetlands for agriculture are other examples of non-random human destruction of complex naturally evolved ecosystems.

It pays us to think conservatively when we convert the earth's landscape for our own physical and aesthetic needs. Species diversity evolved for a purpose and I believe it is to insure ecosystem flexibility under stress. Scientists are still learning how to measure the benefits of biodiversity, and until we have a clearer picture, it is important to save all the species we can.

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