Letters

Net Primary Production: Original Calculations

Bruce L. Godfriaux (Letters, 2 Jan., p. 15) argues that one of us (Paul Ehrlich) exaggerated the fraction of net primary production (NPP) consumed by humans (directly or indirectly) by "several orders of magnitude." Ehrlich's statement was based on our calculations of the fraction of global NPP dominated by humans (*1*). We used databases derived from United Nations–Food and Agriculture Organization statistics and from studies of the global carbon cycle to estimate that 3.9% of terrestrial NPP [5.2 of 132.1 petagrams (Pg), with 1 petagram equal to 1×10^{15} grams] is used directly by humans or our domestic animals (as food, fiber, or wood fuel). An additional 26.8% (35.4 Pg) of terrestrial NPP is co-opted by humanity in that it occurs in wholly human-dominated ecosystems (for example, the nonedible portion of crops or urban lawns) or is destroyed by human activity (for example, consumed by land-clearing fires in the tropics). Finally, we estimate that human activities (especially desertification and the conversion of forest to agricultural lands) have reduced potential NPP by about 17.5 Pg. Overall, 58.1 of a potential 149.8 Pg of terrestrial NPP (38.8%) are used, co-opted, or foregone as a direct result of human activity. These calculations cannot of course be regarded as final—global NPP itself is difficult to estimate—but they are logical, relatively conservative, and based on the best available data.

From these calculations, we concluded (*1*, p. 372) that

> People and associated organisms use [this fraction of NPP] largely, but not entirely, at human direction, and the vast majority of other species must subsist on the remainder. An equivalent concentration of resources into one species and its satellites has probably not occurred since land plants first diversified. The cooption, diversion, and destruction of these terrestrial resources clearly contributes to human-caused extinctions of species and genetically distinct populations—extinctions that could cause a greater reduction in organic diversity than occurred at the Cretaceous-Tertiary boundary 65 million years ago.

We stand by those conclusions.

Godfriaux's calculations are irrelevant to Ehrlich's point and should not pass without comment. From the annual yield (wet weight) of tomatoes in fossil-fuel-subsidized greenhouses, he calculates the area of land required to support the present U.S. population (on little more than 50% of the calories per day we now use) and shows that this is a small fraction of his estimate of tillable land in the United States (which is approximately twice the actual tilled land in the United States, a country with a relatively low population density). This calculation might conceivably be relevant to an estimate of the number of people who could be kept alive on Earth if energy and resources were free and our life support systems capable of absorbing infinite waste products. It might even be useful in calculating what could be accomplished if we turned our technical ingenuity toward sharing Earth with other species by minimizing our effects on global food resources. It has nothing to do with estimating the fraction of global NPP that humans use or control today.

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Teacher Training

William Simon (Letters, 16 Jan., p. 267) makes several valid points. However, in his references to teacher training his proposals fall somewhat short of "revolutionary." He is in fact very much in tune with the current situation in many inner city school systems and actually supports the status quo in his assumption that the more elementary the subject matter, the less the requisite expertise of the teacher.

I would argue that at least in science education quite the reverse is the case. My experience indicates that quality science teaching at the middle and high school levels requires a deep conceptual understanding of the themes that pervade natural science. More frequently we find teachers who are able to transmit large bodies of factual information in a given science. I have seen many college freshmen who are able to relate details of DNA structure or the Krebs cycle, but who have little notion of the idea of coded information or of the meaning of cell work. Students with this type of background must often go through a process of "unlearning" details as they simultaneously form integrated concepts.

In a sense, then, Simon is correct in his assertion that "only a few college preparatory or advance placement courses . . . require any special knowledge of the field." In a deeper sense, however, his statement is likely to be misconstrued. Middle and high school science teachers can certainly do without excessive detail in their own education. However, they must somehow be provided with a deep understanding of the integrating conceptual themes in natural science if they are to do more than pass on facts to their students and if we wish them to produce a society of informed citizens capable of some understanding of emergent technologies. In this sense, I believe Simon's proposal misses the mark. One does not produce such teachers by requiring "only a college graduate who has majored in the subject." Granted, experience has shown that advanced degrees may likewise not be the solution. We seem to be led to the conclusion that we should seriously rethink our methods of training teachers. Simply taking bachelors-level graduates with "excellent experience in handling children and young adults," and expecting them to become good science teachers is truly ignoring the heart of the problem.

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William Simon argues that only a few subjects such as languages, art, science, and music "require any special knowledge of the field" and implies that other areas of learning are devoid of recognized principles and can be taught by anyone with the "willingness and ability to relate to young people."

Inadequate exposure of teachers to course content already allows an appalling number of young people to enter college with little understanding of both social and technological aspects of the world in which they will live the rest of their lives. We need more, not less, stress on course content than we now have.

Academic training for teachers of geography and anthropology and philosophy is as essential as for teachers in the physical sciences. Contrary to Simon's implication, knowledge in these disciplines is neither more nor less complex than that of chemistry or mathematics. Marginally educated teachers are no more fit to teach history than to teach biophysics.

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