Your ECOLOGICAL footprint

What Is Your Overall Impact?

For this final chapter it would be nice if you could calculate a single measure that represents your overall impact on the planet. To do so, you would sum the uses and emissions of materials, energy, soil, and land that you calculated for previous chapters' Your Ecological Footprint.

But calculating a single measure is not easy. Think back to those exercises: Some had you track land use, whereas others asked you to trace energy use, water use, soil erosion, or the emissions of pollutants. Can such different impacts be combined?

Actually several measures of overall environmental impact are available. Some measure energy use; others measure the amount of land used. Here we help you translate calculations from previous Your Ecological Footprints to a land-based measure of your overall environmental impact.

You have already done part of this calculation. Chapter 8's Your Ecological Footprint had you calculate the amount of land associated with your use of net primary production. Chapter 16's Your Ecological Footprint had you calculate the amount of land used to grow your food. Chapter 18's Your Ecological Footprint had you calculate the land area used to capture the precipitation you use. It is easy to add these land areas. But how about your use and emissions of materials and energy? How can you convert energy use or carbon dioxide emissions to land area?

To convert oil and other forms of energy to land use, you can ask what would happen if you replaced all of your oil, coal, gas, and electricity with alternative fuels obtained from biomass (see Chapter 22). If you are willing to make this assumption, it is relatively simple to translate energy use to land area. Take the total energy use you calculated for Chapter 20's Your Ecological Footprint (in Btus) and convert it to kilocalories by multiplying by 0.25. Divide that product (in kilocalories) by 3.6 kcal per gram of carbon to get its carbon equivalent. Divide that carbon equivalent by the rate of net primary production in your local biome (see Table 1 in Chapter 8's Your Ecological Footprint). This quotient represents the amount of land required to generate the energy you use.

To illustrate, let's continue with the example given in Chapter 20's Your Ecological Footprint. In that chapter the example indicated a primary energy consumption of 13.65 million Btu per month. This is equivalent to 3.41 million kcal (13.65 million Btu $\times$ 0.25 kcal/Btu = 3.41 million kcal). These 3.41 million kcal are equivalent to 0.95 million grams of carbon (3.41 million kcal/3.41 g carbon/kcal = 0.95 million grams carbon). The example assumed that you went to school in the Boston area, which is located within the temperate forest biome, where net primary production is 701.92 grams of carbon per square meter per year. This implies the biomass from an area of 1,350 m^2 (0.95 million grams carbon/701.92 grams carbon/m^2/year) would be needed to replace the energy used per month.

Now let's calculate the land area that would be required to remove your carbon dioxide emissions from the atmosphere. To do so, recall that net primary production represents the excess of photosynthesis (Equation 5.1) relative to respiration (Equation 5.3). According to these two equations, net primary production represents the amount of carbon dioxide removed from the atmosphere by autotrophs. If you divide the total amount of carbon dioxide emitted, which you calculated for Chapter 13's Your Ecological Footprint, by the rate of net primary production in your local biome (see Table 1 in Chapter 8's Your Ecological Footprint), you can determine the land area needed to remove the carbon dioxide you emit by burning fossil fuels.

To illustrate, the average U.S. citizen emitted about 20 metric tons of carbon dioxide per year in 2005. Of this carbon dioxide, about 27 percent is carbon (the atomic mass of carbon is about 12, the atomic mass of oxygen is about 16, and a molecule of carbon dioxide has an atomic mass of about 44 [12 + 16 + 16], of which 12 is carbon). This implies annual emissions of about 5.5 metric tons of carbon (5.5 metric tons = 20 metric tons carbon dioxide $\times$ 0.27). These 5.5 metric tons are equivalent to 5.5 million grams of carbon (1,000 grams per kilogram, 1,000 kg per metric ton). The temperate forests of the Boston area have a net primary production of 701.92 grams carbon/m^2/year. At this rate, 7,836 m^2 (7,836 m^2 = 5.5 million grams carbon/701.92 grams carbon/m^2/year) of temperate forests would be needed each year to take up the carbon emitted by fossil fuel use by the average U.S. citizen per year.

Interpreting Your Footprint

Summing the amount of land you use directly, in the form of net primary production, and the land equivalents of energy and carbon dioxide emissions gives you an idea of how much land you use. But does this land represent your overall environmental impact in a meaningful way?

We would answer no. You can convert many activities to their land equivalent, but many of these conversions have little ecological meaning. Converting fossil fuel use to land via net primary productivity is difficult. As described in Chapter 22, the conversion of biological energy to useful forms is relatively inefficient, so the conversion based on net primary production alone understates land use significantly. Similarly, converting water consumption to area over which the precipitation falls in Chapter 18 says nothing about whether collecting the precipitation disturbs the land. The land equivalent of your carbon dioxide emissions also contains an important simplification. Net primary production removes carbon dioxide emissions from fossil fuel use only if the plant material is prevented from decaying. Once a plant dies, the carbon it removed from the atmosphere via photosynthesis returns to the atmosphere via decomposition.

We hope you are not surprised by our pessimism about calculating an overall measure of your environmental impact. Reading this book and listening to your professor's lectures should have shown you that you are connected to the environment by many flows of energy and materials. These connections can be thought of as your niche, which any ecologist will tell you cannot be measured in a single unit.

The inability to convert your environmental impact to a single unit can be illustrated by the notion of the limiting nutrient. Remember from Chapter 6 that plants often are limited by a single nutrient. As such, measuring the environmental impact of a plant based on the combined weight of its nutrient use would have little ecological meaning.

ADDITIONAL READING

Wackernagel, M., and W. Rees. *Our Ecological Footprint: Reducing Human Impact on the Earth.* Gabriola Island, BC, and Philadelphia, PA: New Society Publishers, 1995.

STUDENT LEARNING OUTCOME

- Students will be able to explain why efforts to translate their use of energy, materials, and land to a single unit of measure may not be consistent with the ecological concept of a niche.