



## Trophic Structure of the Economy

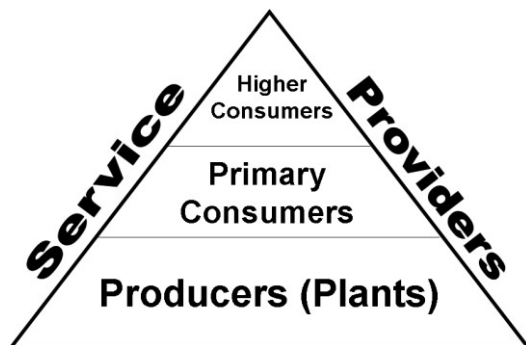
### Sound Byte

Nothing says it more succinctly than the Bible: “All flesh is grass” (Isaiah 40:6). We and all animals are dependent upon plants for our existence and growth. This principle, called “trophic structure” in ecology, has profound implications for economic policy.

### Trophic Levels

All ecosystems have a trophic structure (Figure 1). “Trophic” refers to the flow of energy and nutrition. The most basic trophic categories are producers and consumers. The producers are plants; they literally produce food in the process of photosynthesis. Consumers range from primary to secondary, tertiary, and sometimes even higher.

Primary consumers (for example, rabbits) eat plants. Secondary consumers (for example, foxes) eat mostly primary consumers. Higher-level consumers (for example, wolves) eat a mix of other consumers. High-level omnivores may also eat large quantities of plant material. A good example is the black bear.



**Figure 1. Trophic structure.**

Some species do not fit neatly into the basic trophic levels. For example, scavengers are not predators, but they do eat flesh. Decomposers eat a mix of dead plant and animal material. Pollinators feed on nectar, but not plant tissue. These species may be classified as service providers, and they operate among the basic trophic levels.

The size of the economy of nature – all trophic levels and service sectors in the aggregate – is dependent upon the amount of plant production. “All flesh is grass.”

Although plant production is affected by many factors, including the activities of service providers and other species, it is ultimately limited by stocks of water and flows of sunlight. Water and sunlight are in turn limited by the first law of thermodynamics, which establishes that energy and matter cannot be created or destroyed, but only converted to other forms (such as in the process of photosynthesis). Meanwhile, the second law of thermodynamics establishes that conversion of energy and matter cannot be 100% efficient. A rule of thumb in ecology is that approximately 10% of the biomass from one trophic level is converted to biomass in the next higher trophic level. For example, a hundred tons of grasses, forbs and shrubs may support ten tons of rabbits (and one ton of foxes).

## Trophic Structure of the Human Economy

The trophic structure of the human economy reflects the same ecological principles. The producers are farmers, and we may also consider the extractive sectors (such as logging, fishing, and mining) to occupy the foundation of the economy (Figure 2).

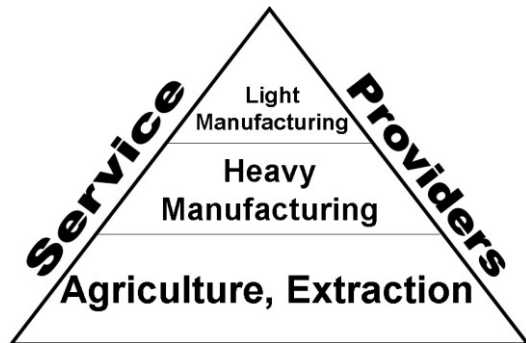


Figure 2. Trophic structure, human economy.

The size of the human economy depends upon the amount of agricultural surplus. As Francois Quesnay pointed out, it is agricultural surplus that frees the hands for the division of labor. Following in Quesnay's footsteps, Adam Smith described how the division of labor gives rise to the "industry of the towns" and the use of money as a unit of exchange. More real money (adjusted for inflation) requires more agricultural surplus.

As in the economy of nature, agricultural production is limited by natural stocks and flows, most notably water and sunlight.

## Combining All Sectors

Trophic levels help us to understand our environmental context. In physical and ecological terms, humans are top-level omnivores (Figure 3). This means that the size of the human economy is limited by the remainder of the economy of nature, pursuant to the laws of thermodynamics.

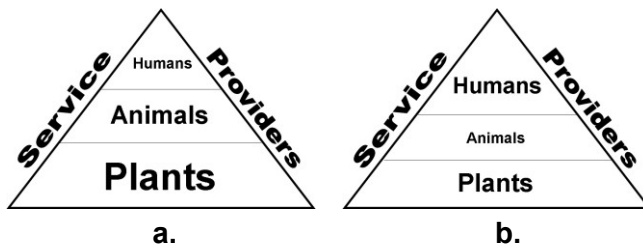


Figure 3. a) Trophic structure of all species combined. Ecological and economic services are provided by non-human species and human sectors. b) Same as in (a) but with economic growth.

Trophic levels also reveal the trade-off between economic growth and biodiversity conservation. The human economy at the top of the pyramid can only expand by out-competing and compressing the ecosystems at the bottom of the pyramid. Expansion of the top can only go so far before breaking the foundation upon which it sits.

## Policy Implications

Along with thermodynamics, trophic principles establish a limit to economic growth. This limit applies in the real sector (that is, in the production and consumption of goods and services) and the monetary sector. In other words, volumes and flows of money (for example, expenditures on gross national product) indicate the level of human impact on the environment. Therefore, expansionary monetary policy leads either to increased environmental impact and erodes long-term economic capacity, or to inflation if the environmental capacity for economic growth has been exceeded.