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ECOLOGICAL PYRAMIDS

BY

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Ecological Pyramid Definition:

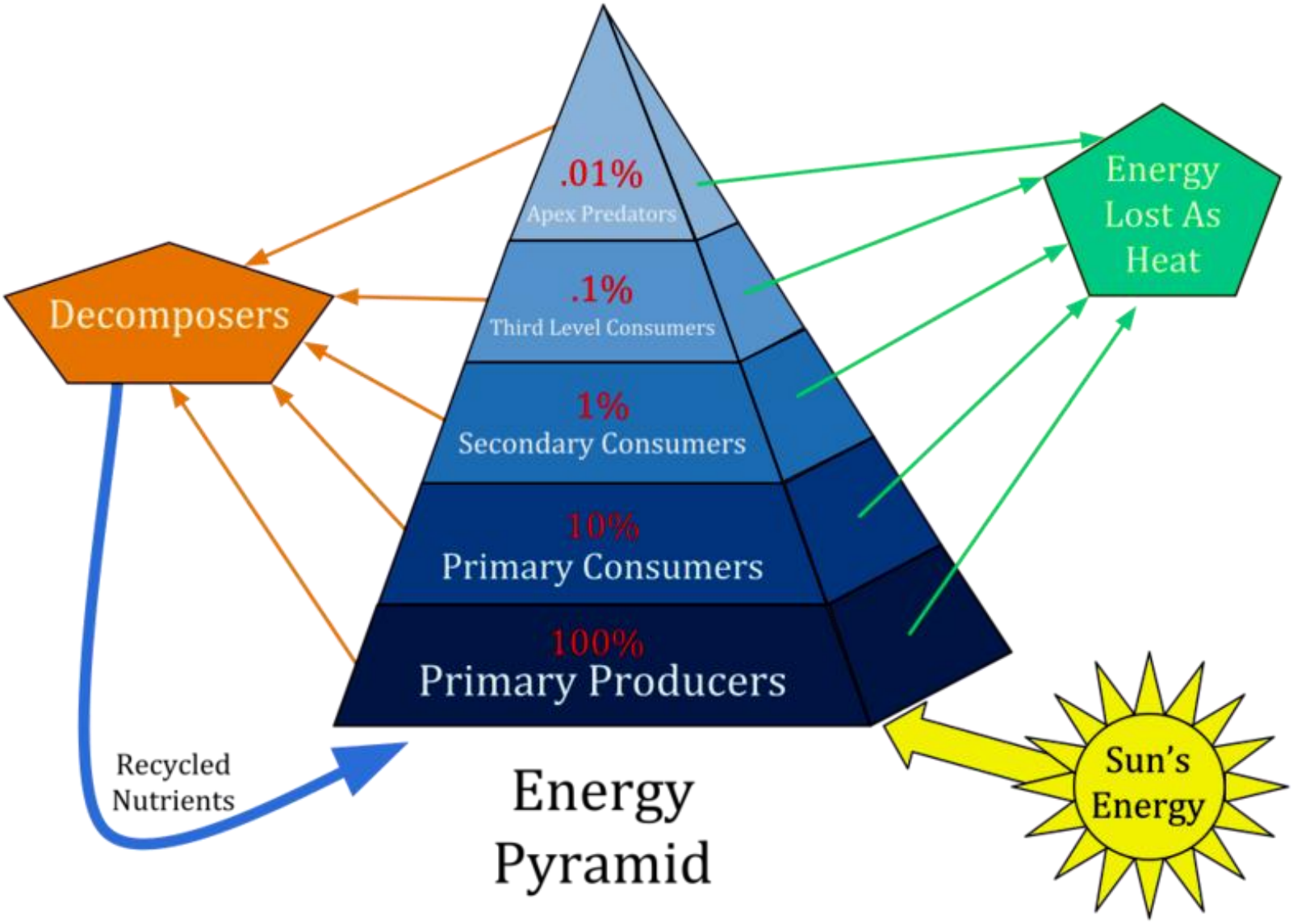
An **ecological pyramid** (also trophic pyramid, Eltonian pyramid, energy pyramid, or sometimes food pyramid) is a graphical representation designed to show the biomass or bioproductivity at each trophic level in a given ecosystem. An ecological pyramid is a graphical representation of the relationship between the different living organisms at different trophic levels.

The concept of pyramid of numbers ("Eltonian pyramid") was developed by Charles Elton (1927). Later, it would also be expressed in terms of

biomass by Bodenheimer (1938). The idea of pyramid of productivity or energy relies on works of G. Evelyn Hutchinson and Raymond Lindeman (1942). It can be observed that these pyramids are in the shape of actual pyramids with the base being the broadest, which is covered by the lowest trophic level, i.e., producers. The next level is occupied by the next trophic level, i.e., the primary consumers and so on. All the calculations for construction of these types of ecological pyramids must take into account all the organisms in a particular trophic level because a sample space of a few numbers or a few species will end up giving a huge level of errors.

Types of Ecological Pyramids:

Three types of ecological pyramids exist. A **pyramid of energy** shows how much energy is retained in the form of new biomass at each trophic level, while a **pyramid of biomass** shows how much biomass (the amount of living or organic matter present in an organism) is present in the organisms. Biomass can be measured by a bomb calorimeter. There is also a **pyramid of numbers** representing the number of individual organisms at each trophic level. Pyramids of energy are normally upright, but other pyramids can be inverted or take other shapes.


.01%
Apex Predators
.1%
Third Level Consumers
1%
Secondary Consumers
10%
Primary Consumers
100%
Primary Producers
Decomposers
Energy Lost As Heat
Recycled Nutrients
Sun's Energy
Energy Pyramid

Ecological pyramids begin with producers on the bottom (such as plants) and proceed through the various trophic levels (such as herbivores that eat plants, then carnivores that eat flesh, then omnivores that eat both plants and flesh, and so on). The highest level is the top of the food chain.

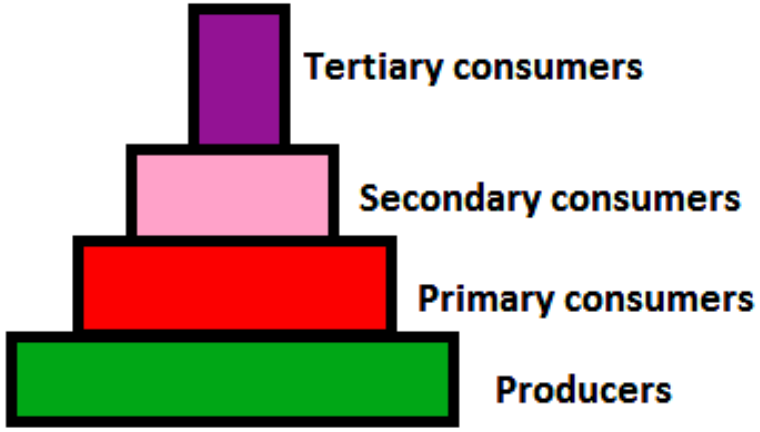
The sun has been included in this diagram, as it's the main source of all energy, as well the decomposers, like bacteria and fungi, which can acquire nutrients and energy from all trophic levels by breaking down dead or decaying organisms. As shown, the nutrients then go back into the soil and are taken up by plants.

The loss of energy to the surroundings is also shown in this diagram, and the total energy transfer has been calculated. We start off with the total amount of energy that the primary producers contain, which is indicated by 100%. As we go up one level, 90% of that energy is used in ways other than to create flesh. What the primary consumers end up with is just 10% of the starting energy, and, 10% of that 10% is lost in the transfer to the next level. That's 1%, and so on. The predators at the apex, then, will only receive 0.01% of the starting energy! This inefficiency in the system is the reason why productivity pyramids are always upright. A pyramid of energy represents how much energy, initially from the sun, is retained or

stored in the form of new biomass at each trophic level in an ecosystem. Typically, about 10% of the energy is transferred from one trophic level to the next, thus preventing a large number of trophic levels. Energy pyramids are necessarily upright in healthy ecosystems, that is, there must always be more energy available at a given level of the pyramid to support the energy and biomass requirement of the next trophic level. Energy moves up the pyramid, starting with the primary producers, or autotrophs, such as plants and algae at the very bottom, followed by the primary consumers, which feed on these plants, then secondary consumers, which feed on the primary consumers, and so on.

The different types of Pyramids are as follows:

Pyramid of Numbers:



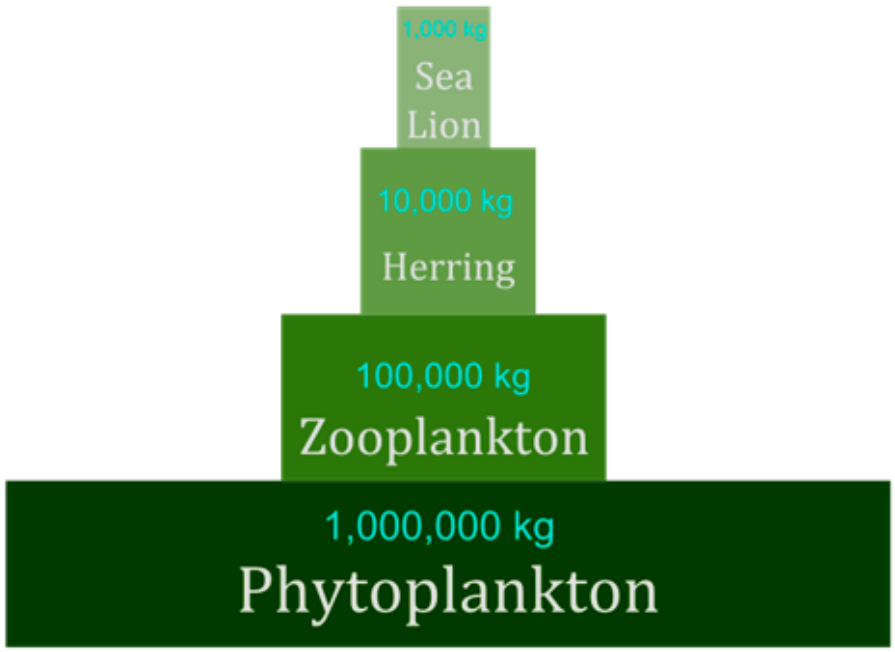
Pyramid of numbers

Pyramid of Numbers

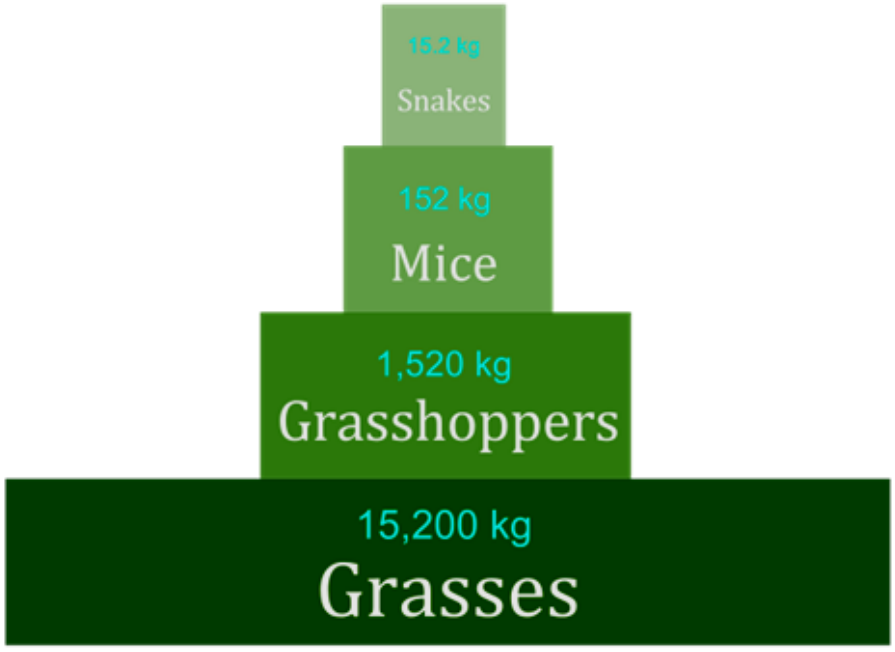
In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. A pyramid of number shows graphically the number of individual organisms involved at each level in a food chain. In other words, it is the graphic representation of number of individuals per unit area of various trophic levels. This shows the number of organisms in each trophic level without any consideration for their individual sizes or biomass. The pyramid of numbers is usually upright except for some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal. The pyramid is not necessarily upright. For example, it will be inverted if beetles are

feeding from the output of forest trees, or parasites are feeding on large host animals. Large number of producers tends to form the base whereas lower number of top predators or carnivores occupies the tip. The shape of the pyramid of numbers varies from ecosystem to ecosystem.

For example, in an aquatic ecosystem or grassland areas, autotrophs or producers are present in large number per unit area. The producers support a lesser number of herbivores, which in turn supports fewer carnivores.



Aquatic Ecosystem



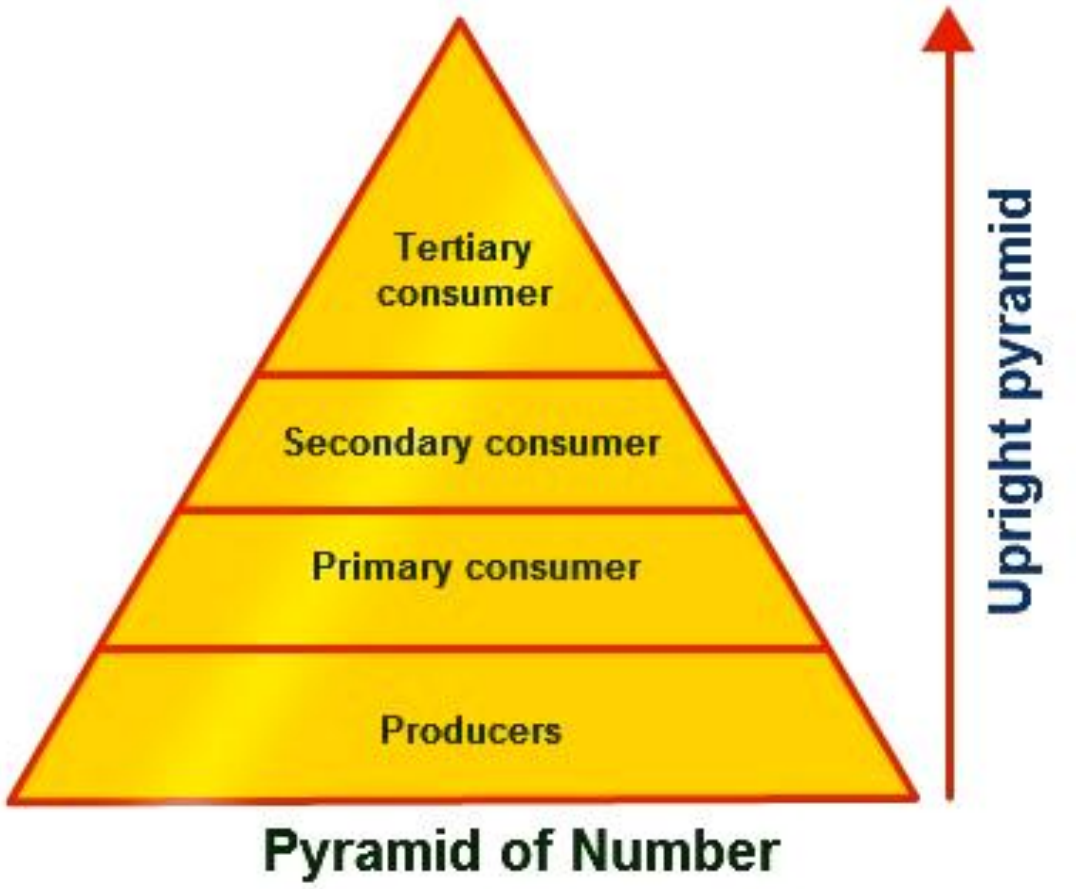
Terrestrial Ecosystem

A pyramid of numbers shows the number of individual organisms involved at each trophic level in an ecosystem. The pyramids are not

necessarily upright. In some ecosystems there can be more primary consumers than producers.

Upright Pyramid of Numbers:

In upright pyramid of numbers, the number of individuals decreases from the lower level to the higher level. This type of pyramid is usually found in the grassland ecosystem and the pond ecosystem. The grass in a grassland ecosystem occupies the lowest trophic level because of its abundance.



Pyramid of Number

Next comes the primary producers – the herbivores (for example – grasshopper). The number of grasshoppers is quite less than that of

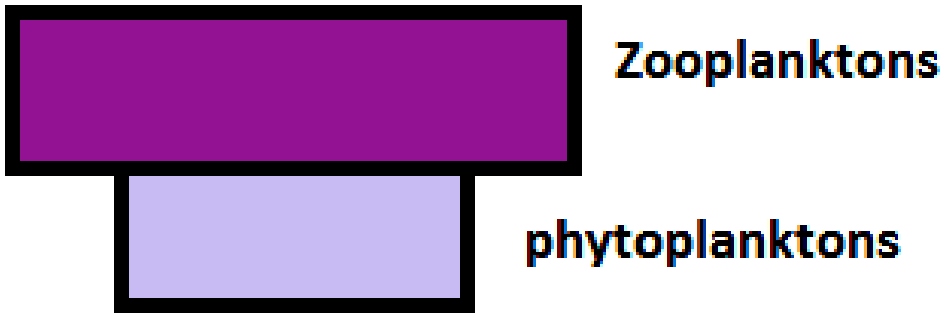
grass. Then, there are the primary carnivores, for example, the rat whose number is far less than the grasshoppers. The next trophic level is the secondary consumers such as the snakes who feed on the rats. Then, there are the top carnivores such as the hawks who eat snakes and whose number is less than the snakes.

The number of species decreases towards the higher levels in this pyramidal structure.

Inverted Pyramid of Numbers:

Here, the number of individuals increase from the lower level to the higher trophic level. For example, the tree ecosystem.

Pyramid of Biomass:



Pyramid of biomass in oceans

Pyramid of Biomass

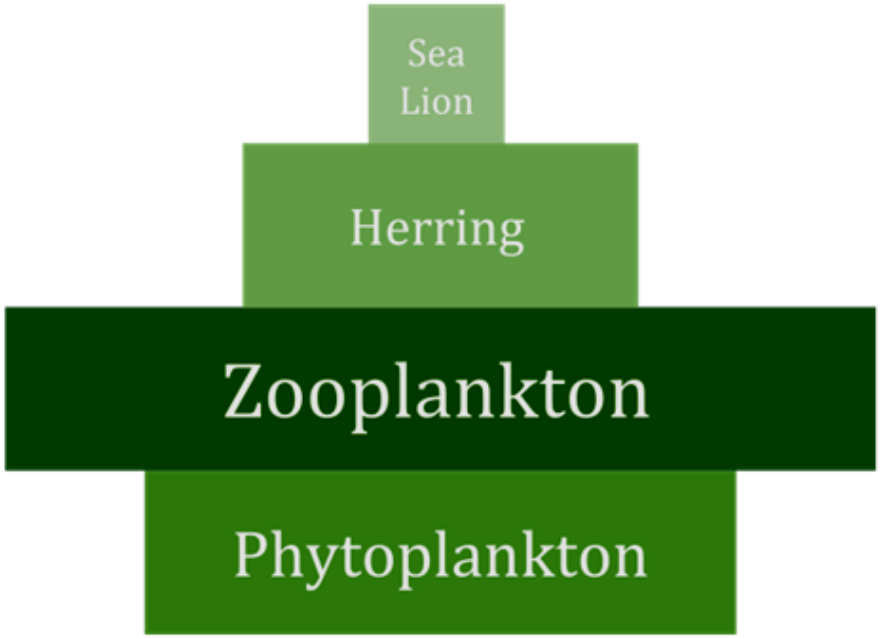
In this particular type of ecological pyramid, each level takes into account the amount of biomass produced by each trophic level. A pyramid of

biomass shows the relationship between biomass and trophic level by quantifying the biomass present at each trophic level of an ecological community at a particular time. It is a graphical representation of biomass (total amount of living or organic matter in an ecosystem) present in unit area in different trophic levels. Typical units are grams per square meter, or calories per square meter. It is drawn with the producers at the base and the top carnivores at the tip.

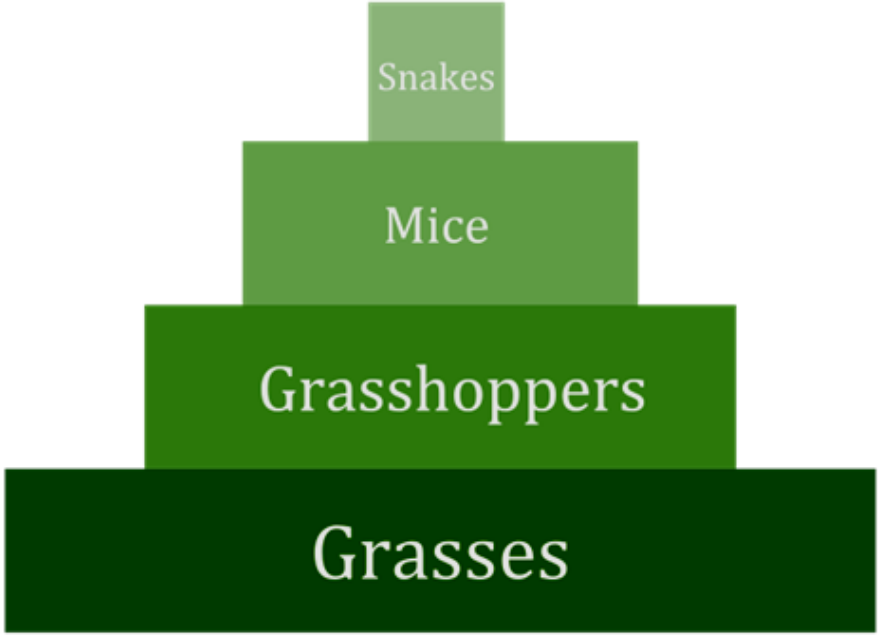
Pyramid of biomass is generally ascertained by gathering all organisms occupying each trophic level separately and measuring their dry weight.

Each trophic level has a certain mass of living material at a particular time called standing crop, which is measured as the mass of living organisms (biomass) or the number in a unit area. The pyramid of biomass is also upright except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons. The pyramid of biomass may be "inverted". For example, in a pond ecosystem, the standing crop of phytoplankton, the major producers, at any given point will be lower than the mass of the heterotrophs, such as fish and insects. This is explained as the

phytoplankton reproduce very quickly, but have much shorter individual lives.



Aquatic Ecosystem

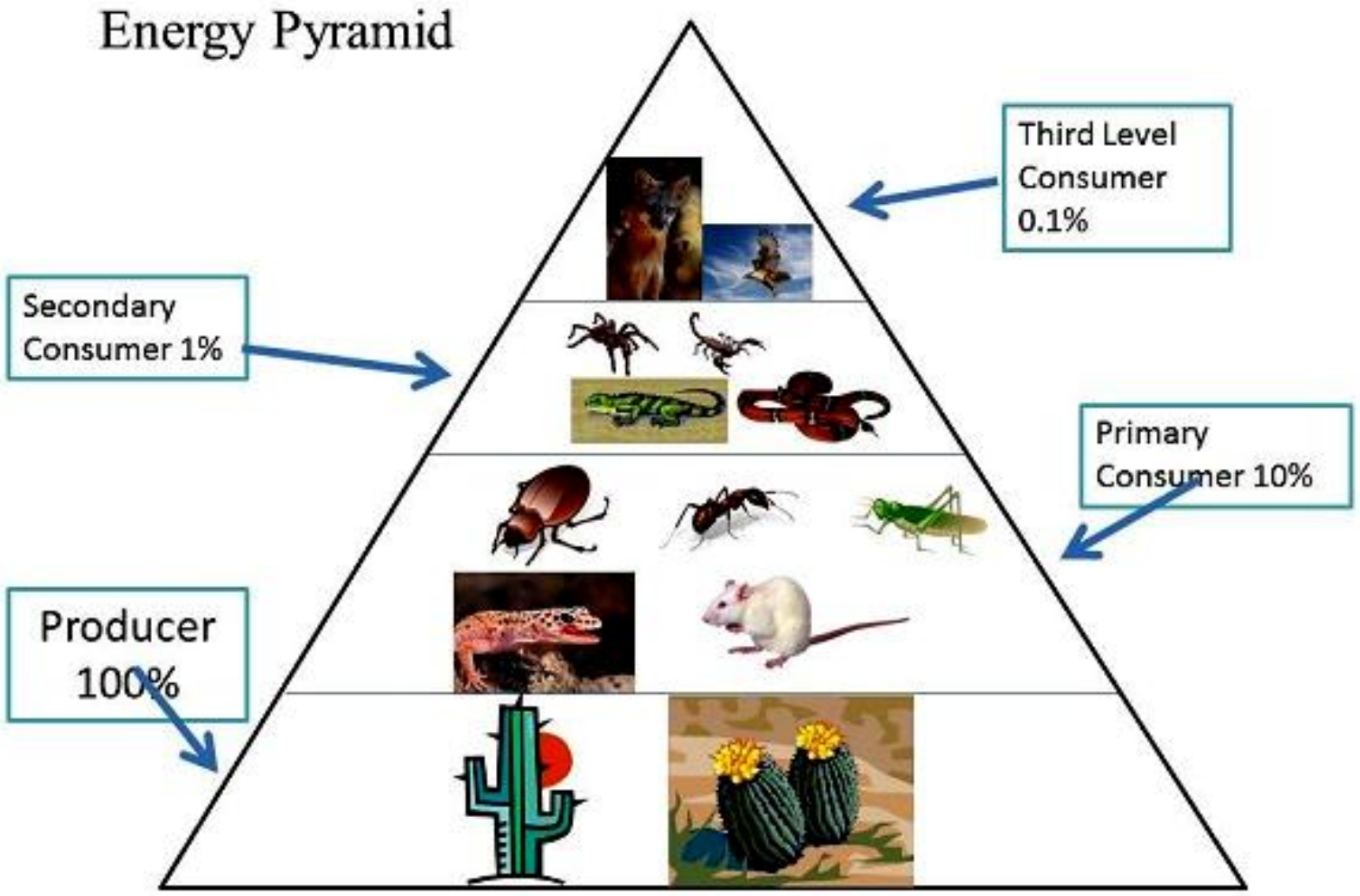


Terrestrial Ecosystem

A pyramid of biomass shows the total biomass of the organisms involved at each trophic level of an ecosystem. These pyramids are not necessarily upright. There can be lower amounts of biomass at the bottom of the pyramid if the rate of primary production per unit biomass is high.

Upright Pyramid of Biomass:

Ecosystems found on land mostly have pyramids of biomass with large base of primary producers with smaller trophic level perched on top, hence the upright pyramid of biomass.


Energy Pyramid
Third Level Consumer 0.1%
Secondary Consumer 1%
Primary Consumer 10%
Producer 100%

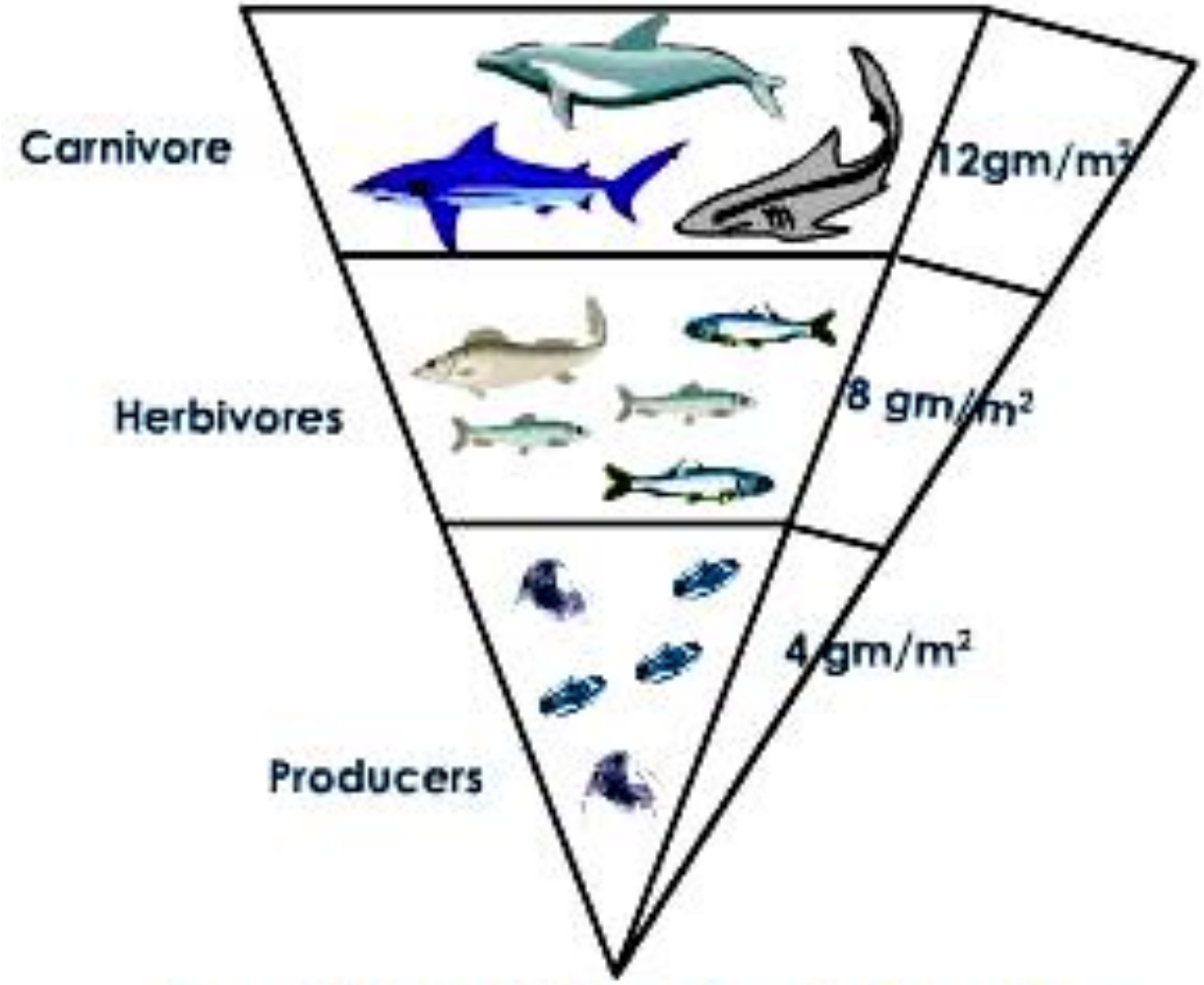
The biomass of autotrophs or producers is at the maximum. The biomass of next trophic level, i.e. primary consumers is less than the producers. Similarly, the other consumers such as secondary and tertiary consumers are comparatively less than its lower level respectively. The top of the pyramid has very less amount of biomass.

Inverted Pyramid of Biomass:

On the other hand, a reverse pyramidal structure is found in most aquatic ecosystems. Here, the pyramid of biomass may assume an

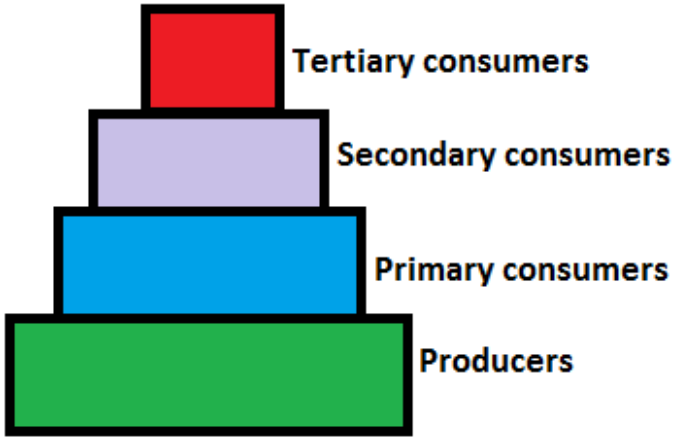
inverted pattern. However, pyramid of numbers for aquatic ecosystem is upright.

In a water body, the producers are tiny phytoplankton that grow and reproduce rapidly. In this condition, the pyramid of biomass has a small base, with the producer biomass at the base providing support to consumer biomass of large weight. Hence, it assumes an inverted shape.



Inverted Pyramid in an Aquatic Ecosystem

Pyramid of Energy:



Pyramid of energy

Pyramid of Energy

A pyramid of energy or pyramid of productivity shows the production or turnover (the rate at which energy or mass is transferred from one trophic level to the next) of biomass at each trophic level. Instead of showing a single snapshot in time, productivity pyramids show the flow of energy through the food chain. Typical units are grams per square meter per year or calories per square meter per year. As with the others, this graph shows producers at the bottom and higher trophic levels on top.

When an ecosystem is healthy, this graph produces a standard ecological pyramid. This is because in order for the ecosystem to sustain itself, there must be more energy at lower trophic levels than there is at higher trophic levels. This allows organisms on the lower levels to not only maintain a stable population, but also to transfer energy up the pyramid. The exception to this generalization is when portions of a food web are supported by inputs of resources from outside the local community. In small, forested streams, for example, the volume of higher levels is greater than could be supported by the local primary production.

Energy usually enters ecosystems from the Sun. The primary producers at the base of the pyramid use the solar radiation to power photosynthesis, which produces food. However most wavelengths in solar radiation cannot be used for photosynthesis, so they are reflected back into space or absorbed elsewhere and converted to heat. Only 1 to 2 percent of the energy from the sun is absorbed by photosynthetic processes, and converted into food. When energy is transferred to higher trophic levels, on average only about 10% is used at each level to build new biomass, becoming stored energy. The rest goes to metabolic processes such as growth, respiration, and reproduction.

Advantages of the pyramid of energy as a representation:

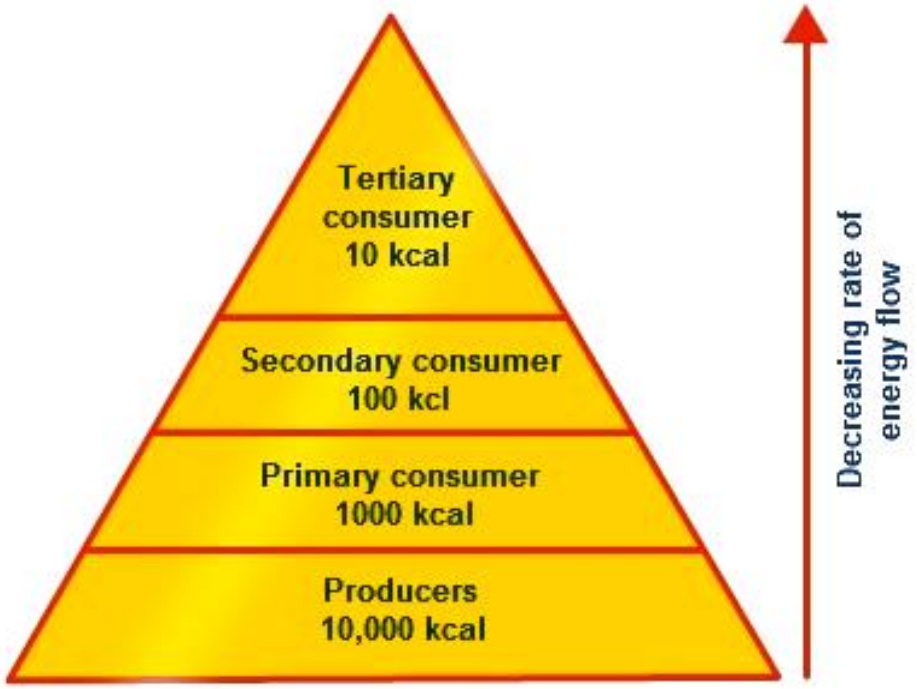
1. It takes account of the rate of production over a period of time.
2. Two species of comparable biomass may have very different life spans. Thus a direct comparison of their total biomasses is misleading, but their productivity is directly comparable.
3. The relative energy chain within an ecosystem can be compared using pyramids of energy; also different ecosystems can be compared.
4. There are no inverted pyramids.
5. The input of solar energy can be added.

Disadvantages of the pyramid of energy as a representation:

1. The rate of biomass production of an organism is required, which involves measuring growth and reproduction through time.
2. There is still the difficulty of assigning the organisms to a specific trophic level. As well as the organisms in the food chains there is the problem of assigning the decomposers and detritivores to a particular trophic level.

Pyramid of energy is the only type of ecological pyramid, which is always upright as the energy flow in a food chain is always unidirectional. Also,

with every increasing trophic level, some energy is lost into the environment. Ecological pyramid is useful in quantifying the energy transfer from one organism to another along the food chain.



Pyramid of Energy

Energy decreases as one moves through the trophic levels from the bottom to the top of the pyramid. Thus, the energy pyramid is always upward.

Function of Ecological Pyramid:

1. An ecological pyramid not only shows us the feeding patterns of organisms in different ecosystems, but can also give us an insight into how inefficient energy transfer is, and show the influence that a change in numbers at one trophic level can have on the trophic levels above and below it.

2. Also, when data are collected over the years, the effects of the changes that take place in the environment on the organisms can be studied by comparing the data.

3. If an ecosystem's conditions are found to be worsening over the years because of pollution or overhunting by humans, action can be taken to prevent further damage and possibly reverse some of the present damage.

Importance of Ecological Pyramid:

The importance of ecological pyramid can be explained in the following points:

1. They show the feeding of different organisms in different ecosystems.
2. It shows the efficiency of energy transfer.
3. The condition of the ecosystem can be monitored, and any further damage can be prevented.

Limitations of the Ecological Pyramid:

1. More than one species may occupy multiple trophic levels as in case of the food web. Thus, this system does not take into account food webs.
2. The saprophytes and decomposers are not given any place in ecological pyramids. They are not considered in any of the pyramids even though they form an important part of the various ecosystems.
3. These pyramids are applicable only to simple food chains, which usually do not occur naturally.

4. These pyramids do not deliver any concept in relation to variations in season and climate.
5. They do not consider the possibility of the existence of the same species at different levels i.e. belonging to two or more trophic levels.
6. It assumes a simple food chain and does not accommodate a food web.

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THANK YOU