Primary production

- ✓ Productivity is the accrual of matter and energy in biomass.
- ✓ The first step in this process (termed primary productivity) is performed by green plants, which are the only organisms capable of capturing the electro-magnetic energy of the sun and converting it to the chemical energy of reduced carbon compounds (i.e., photosynthates).
- ✓ Secondary productivity results when heterotrophic organisms consume plant tissues and convert some proportion of that matter and energy to their own biomass.

Climate, water and nutrients as a main driving force of primary productivity

- ✓ The availability of water and nutrients is the major factor governing carbon input to ecosystems.
- ✓ Photosynthesis is the process by which most carbon and chemical energy enter ecosystems.
- ✓ The proximate controls over photosynthesis by a single leaf are the availability of reactants such as light energy and CO_2; temperature, which governs reaction rates; and the availability of nitrogen, which is required to produce photosynthetic enzymes.

- ✓ Photosynthesis at the scale of ecosystems is termed gross primary production (GPP).
- ✓ Like photosynthesis by individual leaves, GPP varies diurnally and seasonally in response to changes in light, temperature, and nitrogen supply.
- ✓ Differences among ecosystems in annual GPP, however, are determined primarily by the quantity of leaf area and the length of time that this leaf area is photosynthetically active.
- ✓ Leaf area and photosynthetic season, in turn, depend on the availability of soil resources (water and nutrients), climate, and time since disturbance.

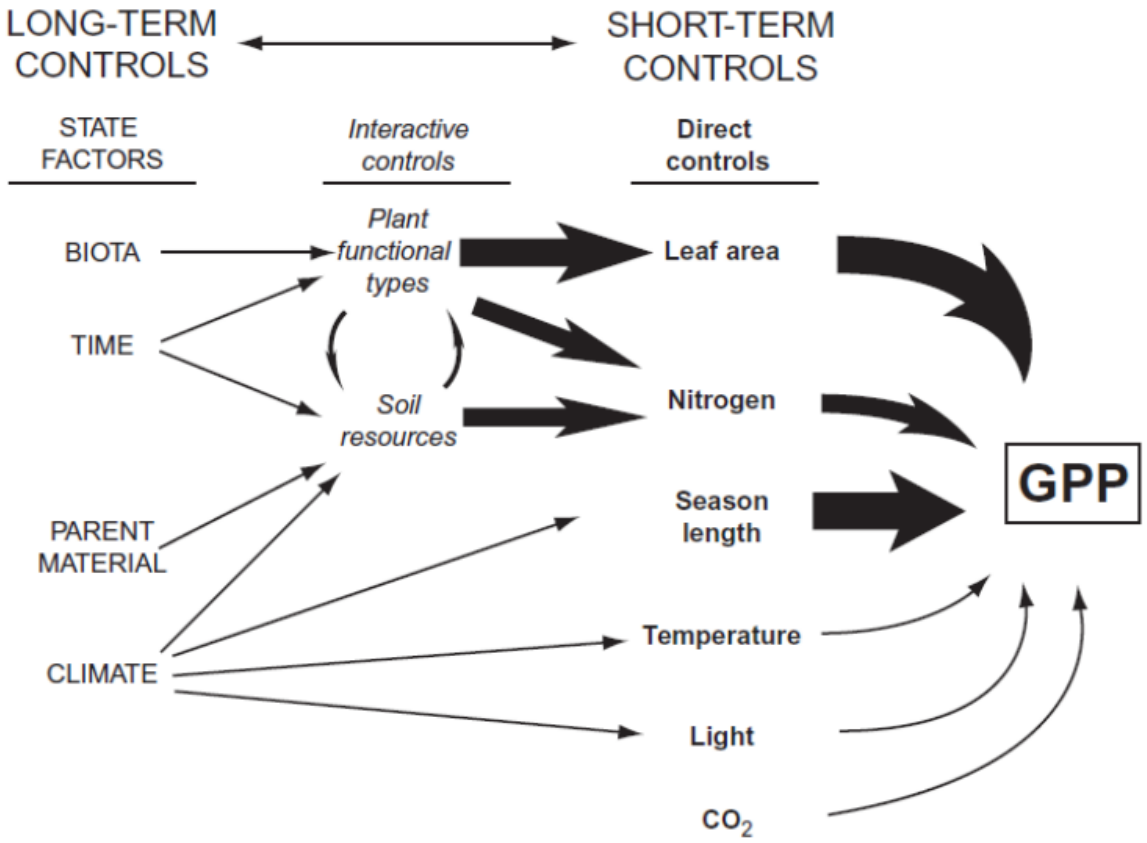


Figure 3.1. The major factors governing gross primary production (GPP) in ecosystems. These controls range from the direct controls, which determine the diurnal and seasonal variations in GPP, to the interactive controls and state factors, which are the ultimate causes of ecosystem differences in GPP. Thickness of the arrows associated with direct controls indicates the strength of the effect. The factors that account for most of the variation in GPP among ecosystems are leaf area and length of the photosynthetic season, which are ultimately determined by the interacting effects of soil resources, climate, vegetation, and disturbance regime (Chapin et al. 2011).

Global Carbon Cycle and Productivity

- ✓ The global carbon cycle is a complex set of processes involving three main components: the land; the oceans; and the atmosphere.
- ✓ Through natural flows, hundreds of billions of tons of carbon are exchanged with the atmosphere.
- ✓ However, this number pales in comparison to the amount of carbon stored in stocks .
- ✓ The carbon cycle is the biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, hydrosphere, and atmosphere of the Earth.
- ✓ Along with the nitrogen cycle and the water cycle, the carbon cycle comprises a sequence of events that are key to making the Earth capable of sustaining life; it describes the movement of carbon as it is recycled and reused throughout the biosphere.

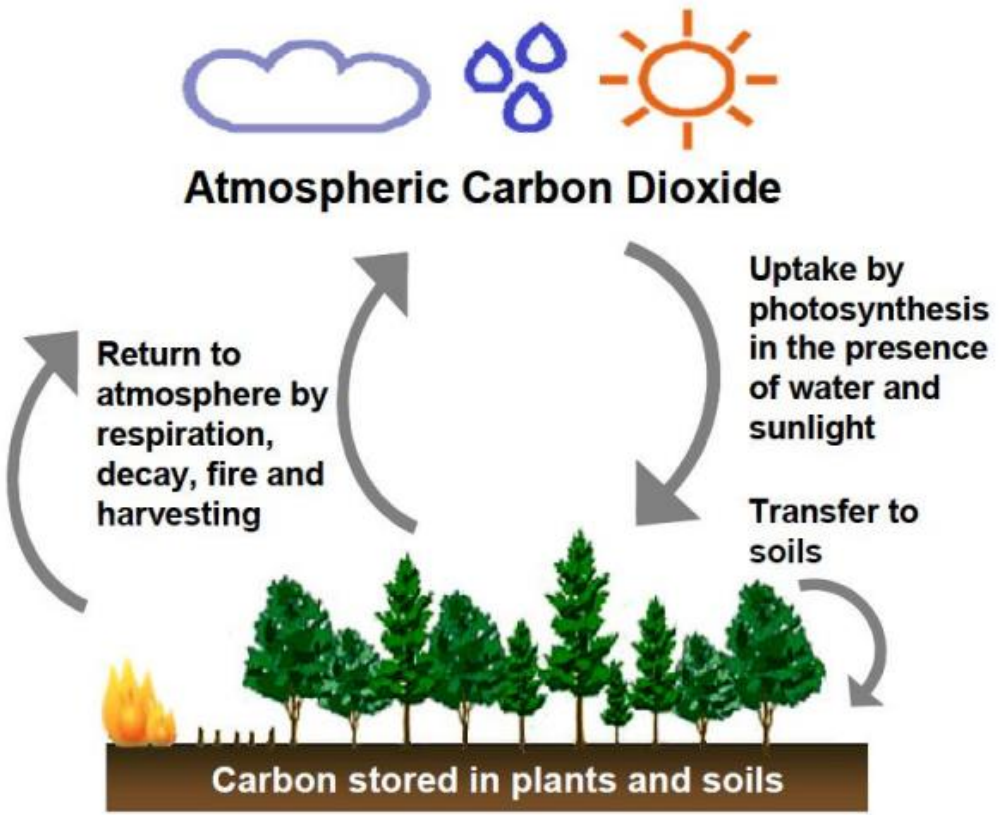


Figure 3.2. A sub-cycle within the global carbon cycle. Carbon continuously moves between the atmosphere, plants and soils through photosynthesis, plant respiration, harvesting, fire and decomposition.

- ✓ On a global basis, this processes transfers large amounts of carbon from one pool (the atmosphere) to another (plants).
- ✓ Over time, these plants die and decay, are harvested by humans, or are burned either for energy or in wildfires.
- ✓ All of these processes are fluxes that can cycle carbon among various pools within ecosystems and eventually releases it back to the atmosphere.
- ✓ Viewing the Earth as a whole, individual cycles like this are linked to others involving oceans, rocks, etc. on a range of spatial and temporal scales to form an integrated global carbon cycle .

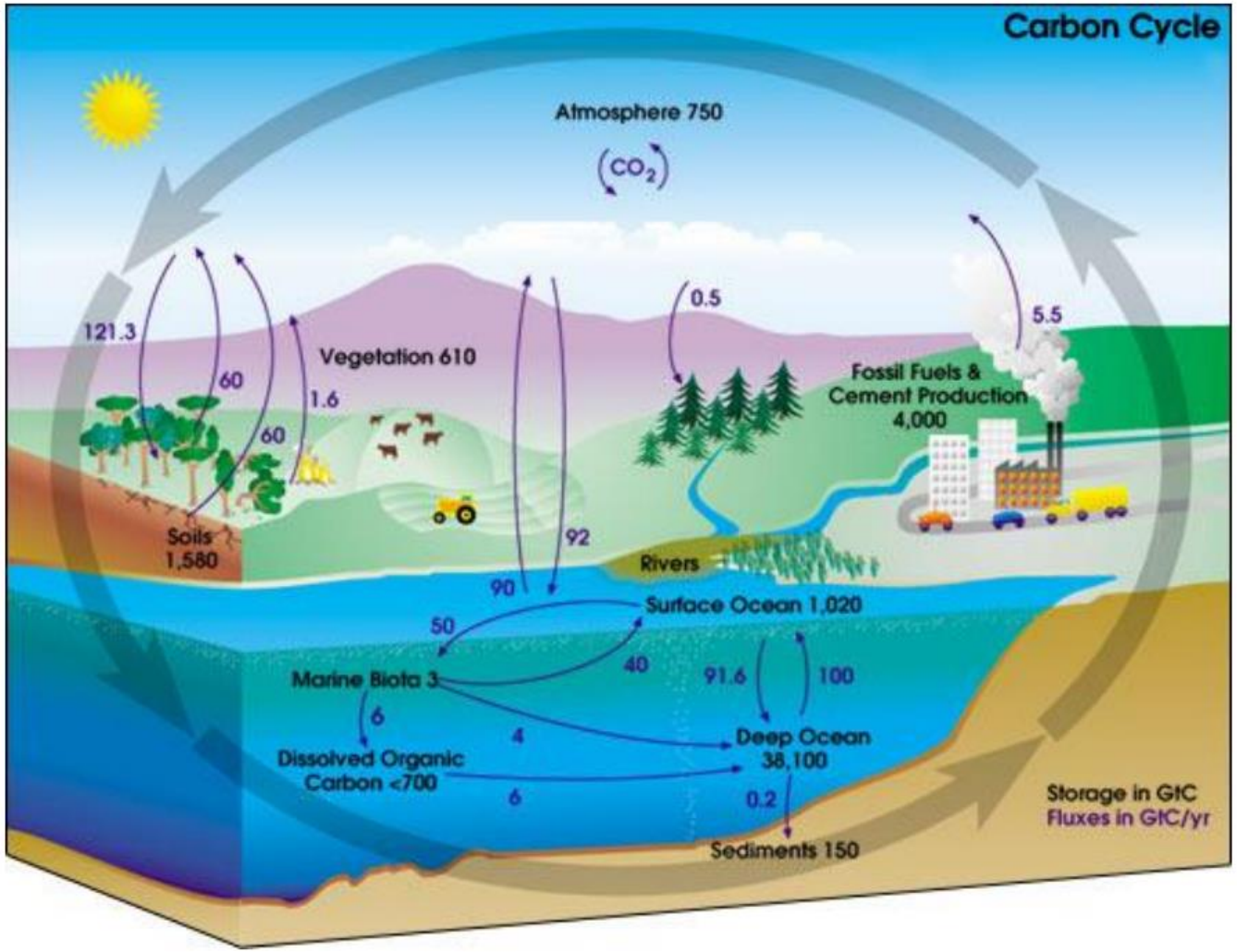


Figure 3.3. A simplified diagram of the global carbon cycle. In any given year, tens of billions of tons of carbon move between the atmosphere, hydrosphere, and geosphere. Human activities add about 5.5 billion tons per year of carbon to the atmosphere. The illustration above shows total amounts of stored carbon in black, and annual carbon fluxes in purple. (Illustration courtesy NASA Earth Science Enterprise). Source: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html

- ✓ The carbon cycle has a large effect on the function and well being of our planet.
- ✓ Globally, the carbon cycle plays a key role in regulating the Earth's climate by controlling the concentration of carbon dioxide in the atmosphere.
- ✓ Carbon dioxide (CO2) is important because it contributes to the greenhouse effect, in which heat generated from sunlight at the Earth's surface is trapped by certain gasses and prevented from escaping through the atmosphere.
- ✓ The greenhouse effect itself is a perfectly natural phenomenon and, without it, the Earth would be a much colder place. But as is often the case, too much of a good thing can have negative consequences, and an unnatural buildup of greenhouse gasses can lead to a planet that gets unnaturally hot.

Photosynthesis

- ✓ Photosynthesis is a process used by plants and other organisms to convert light energy, normally from the sun, into chemical energy that can be used to fuel the organisms activities.
- ✓ Carbohydrates, such as sugars, are synthesized from carbon dioxide and water.
- ✓ Oxygen is also released, mostly as a waste product.
- ✓ Most plants, most algae, and cyanobacteria perform the process of photosynthesis, and are called photoautotrophs.
- ✓ Photosynthesis maintains atmospheric oxygen levels and supplies all of the organic compounds and most of the energy necessary for all life on Earth.

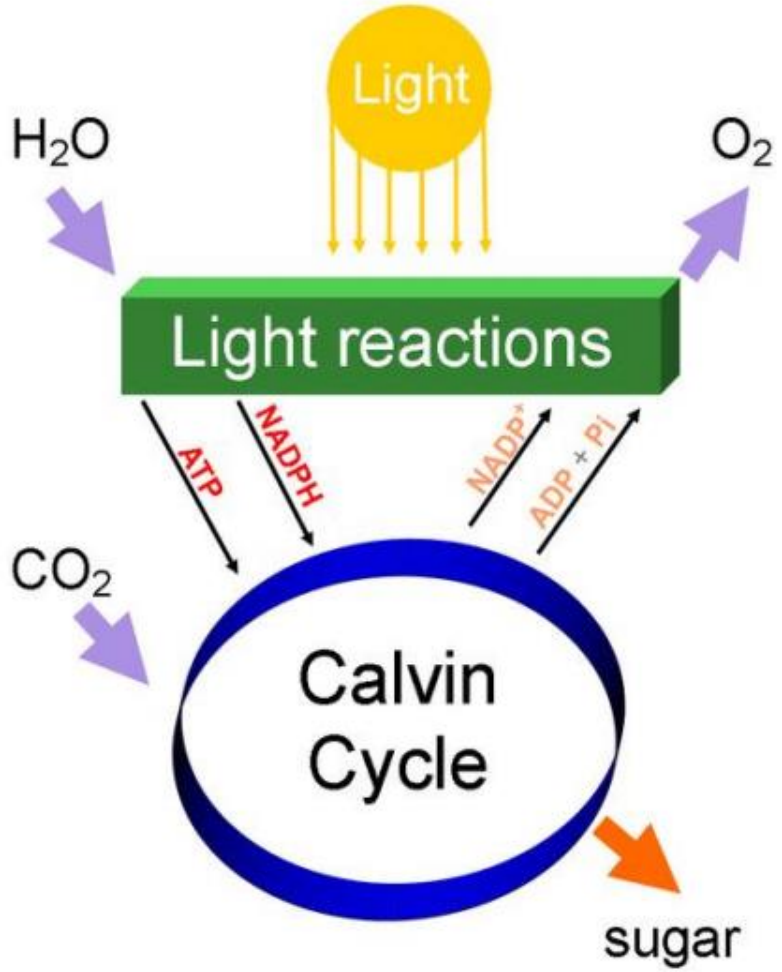
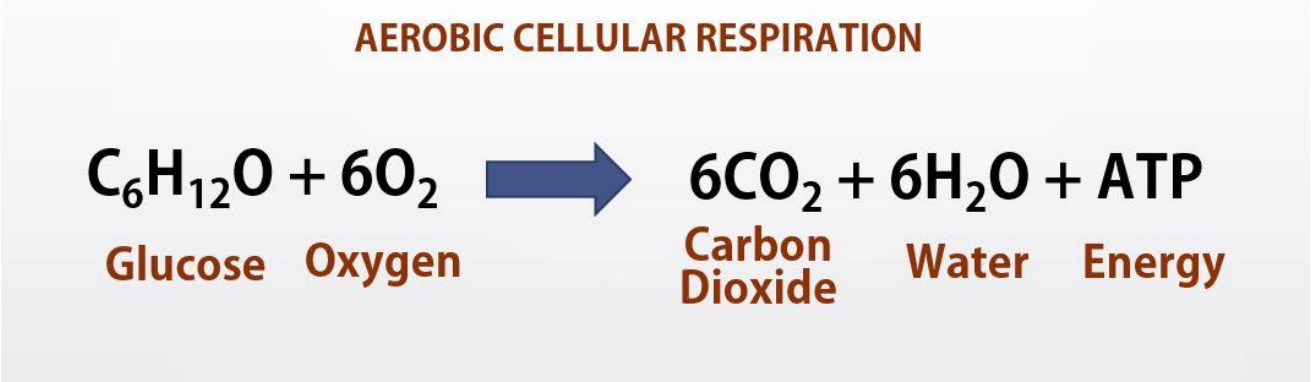


Figure 3.4. A simplified diagram of photosynthesis. Photosynthesis changes sunlight into chemical energy, splits water to liberate O_2, and fixes CO_2 into sugar.
(Source: http://en.wikipedia.org/wiki/File:Simple_photosynthesis_overview.svg)

Autotrophic respiration

- ✓ Autotrophic respiration (Ra) involves the oxidation of organic substances to CO_2 and water, with the production of ATP and reducing power (NADPH) Total autotrophic respiration consists of two major components associated with the metabolic energy expended in the synthesis of new tissue and in the maintenance of living tissue already synthesized.



Gross and Net production

- ✓ Gross primary production (GPP) is the amount of chemical energy as biomass that primary producers create in a given length of time.
- ✓ (GPP is sometimes confused with Gross Primary productivity, which is the rate at which photosynthesis or chemosynthesis occurs.)

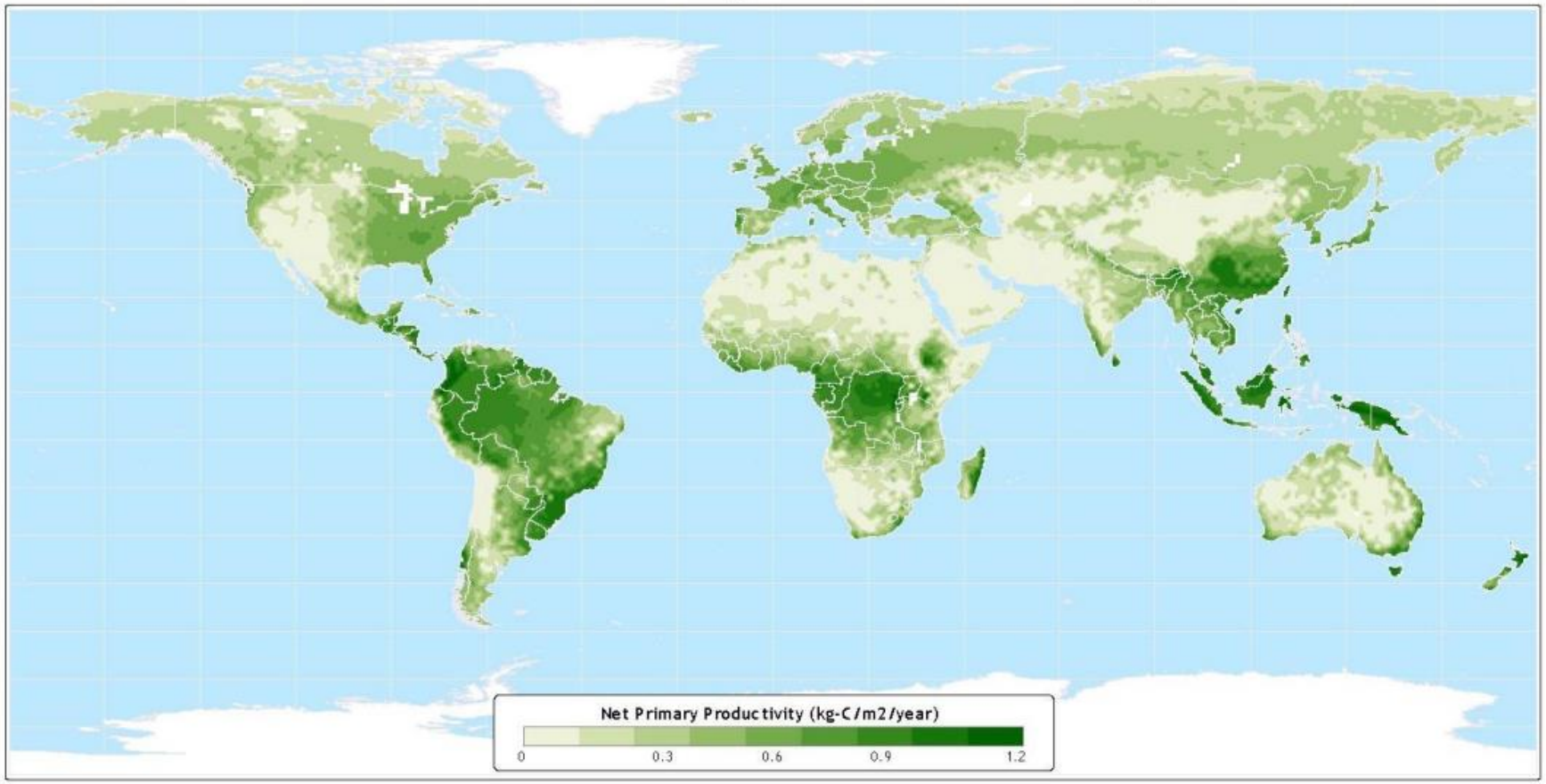
- ✓ Some fraction of this fixed energy is used by primary producers for cellular respiration and maintenance of existing tissues (i.e., "growth respiration" and "maintenance respiration").

- ✓ The remaining fixed energy (i.e., mass of photosynthate) is referred to as net primary production (NPP). NPP = GPP - respiration [by plants]

NPP = GPP - respiration [by plants]

- ✓ Net primary production is the rate at which all the plants in an ecosystem produce net useful chemical energy; it is equal to the difference between the rate at which the plants in an ecosystem produce useful chemical energy (GPP) and the rate at which they use some of that energy during respiration. Some net primary production goes toward growth and reproduction of primary producers, while some is consumed by herbivores.

Net Primary Productivity



Data taken from: IBIS Simulation
(Kucharik, et al. 2000)
(Foley, et al. 1996)

Atlas of the Biosphere
Center for Sustainability and the Global Environment
University of Wisconsin - Madison

Figure 3.4. Net Primary Productivity (NPP).