This page has been archived and is no longer updated Home Library Blogs NATUREJOBS Ecosystem Ecology Ecosystem Ecology IA forested watershed receives inputs of carbon through photosynthesis, inputs of nitrogen from nitrogen-fixing bacteria, as well as through the deposition of atmospheric nitrogen, inputs of phosphorus from the slow weathering of bedrock, and inputs of water from precipitation.An experimental reference watershed at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire, USA Figure 8: An experimental reference watershed at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire, USA Researchers have manipulated entire watersheds, for example by whole-tree harvesting, and then monitored losses of various elements.Nature Education Knowledge 3(10):20 Share Using Reddit StumbleUpon Share with Google+ Share with Twitter Share with Facebook Email Print Bookmark Aa Aa Aa Conserving mass The Law of Conservation of Mass The Law of Conservation of Mass dates from Antoine Lavoisier's 1789 discovery that mass is neither created nor destroyed in chemical reactions.Hypothetical pathway of a carbon atom through an ecosystem Figure 1: Hypothetical pathway of a carbon atom through an ecosystem Because elements are neither created nor destroyed under normal circumstances, individual atoms that compose living organisms have long histories as they cycle through the biosphere.Outputs include gaseous pathways (e.g., H2O losses through evapotranspiration, CO2 production as respiration, N2 produced by denitrifying bacteria) and dissolved pathways (nutrients and carbon dissolved in stream water).The whole-tree harvesting of watershed 2 in 1965 affected the uptake and loss of nutrients and elements within the forest ecosystem and was followed by high loss rates of nitrate, hydrogen ions, and calcium ions in stream waters for several years.An individual atom of a biologically important element, such as carbon, may have spent 65 million years buried as coal before being burned in a power plant, followed by two decades in Earth's atmosphere before being dissolved in the ocean, and then taken up by an algal cell that was consumed by a copepod before being respired and again entering Earth's atmosphere (Figure 1).The extinction of the majestic Irish Elk (Megaloceros giganteus) is thought to have been caused by the shortened growing season that occurred during the last ice age, which reduced the availability of the calcium and phosphorus these animals needed to grow their enormous antlers.The biomolecules that are the building blocks of life (proteins, lipids, carbohydrates, and nucleic acids) are composed of a relatively small subset of the hundred or so naturally occurring elements.The struggle to obtain nutrients from poor quality diets influences feeding behavior and digestive physiology and has led to epic migrations and seemingly bizarre behavior such as geophagy (feeding on materials such as clay and chalk).In 1965, an entire experimental watershed was whole-tree harvested, resulting in large increases in nitrate and calcium losses relative to an uncut reference watershed (Figure 8).Mass Balance of Elements in Organisms A forest system Figure 3: A forest system Because of conservation of mass, if inputs exceed outputs, the biomass of a compartment increases (such as in an early successional forest).By contrast, among vertebrates structural materials such as bones (made of calcium phosphate) account for the majority of an organism's phosphorus content.Among mammals, black-tailed deer (Odocoileus columbianus; Figure 6) have a relatively high phosphorus demand due to their annual investment in calcium- and phosphorus-rich antlers.After calculating inputs to the ecosystem (by sampling precipitation, dry deposition, and nitrogen fixation), they could also construct mass

balances.Cities also produce large quantities of waste products -- with solid waste sent to landfills, CO2 (and other pollutants) produced from the combustion of fossil fuels being released to the atmosphere.Individual organisms, watersheds, and cities receive materials (inputs), transform them, and export them (outputs) sometimes in the form of waste.For example, the seasonal mass migration of Mormon crickets (Anabrus simplex) across western North America in search of two nutrients: protein and salt.This landscape has similar-sized, discreet watersheds drained by streams and underlain by impermeable bedrock.By measuring the concentration of nutrients and ions in stream water, they could quantify the losses of these materials from the ecosystem.Nutrients from sewage and from fertilizer runoff can end up in rivers where they will fertilize downstream aquatic ecosystems.Traditional agricultural practices emphasized efficiency, with most production staying on the farm -- food for livestock was produced on the farm, food for farmers' families was produced on the farm, and plant and animal waste was composted for use as fertilizer on the farm.Lead Editor: ECOSYSTEM ECOLOGY The Conservation of Mass By: Robert W. Sterner (Department of Ecology, Evolution, and Behavior, University of Minnesota), Gaston E. Small (Department of Ecology, Evolution, and Behavior, University of Minnesota) & James M. Hood (Department of Ecology, Evolution, and Behavior, University of Minnesota) (C) 2011 Nature Education Citation: Sterner, R. W., Small, G. E. & Hood, J. M. (2011) The Conservation of Mass.View Terms of Use Life and the Law of Conservation of Mass Ecosystems are represented as a network of various biotic and abiotic compartments, connected through the exchange of materials and energy.Living organisms are primarily made of six elements: oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus.Ecosystems can be thought of as a battleground for these elements, in which species that are more efficient competitors can often exclude inferior competitors.Though most ecosystems contain so many individual reactions, it would be impossible to identify them all, each of these reactions must obey the Law of Conservation of Mass -- the entire ecosystem must also follow this same constraint.When an organism dies, the atoms that were bound in biomolecules return to simpler molecules in the atmosphere, water and soil through the action of decomposers.Additionally, researchers could experimentally manipulate these watersheds to measure the effects of disturbance on nutrient retention.Therefore, in the everyday world of Earth, from the peak of the highest mountain to the depths of the deepest ocean, atoms are not converted to other elements during chemical reactions.Figure 2: Ecosystems are represented as a network of various biotic and abiotic compartments, connected through the exchange of materials and energy.Mass balance ensures that the carbon formerly locked up in biomass must go somewhere; it must reenter some other compartment of some ecosystem.When outputs exceed inputs, the biomass of a compartment decreases (e.g., a forest being harvested).RNA has a high phosphorus content (~9% by mass), and in microbes and invertebrates RNA accounts for a large fraction of an organism's total phosphorus content.Animals, particularly those that feed on plants (herbivores) or detritus (detritivores), often consume diets that do not include enough of the nutrients they need.Some of this material can be stored internally, but this is a limited option and excess carbon storage can be harmful, just as obesity is harmful to humans.Excess nutrients are released in feces or urine or sometimes it is respired (i.e., released as carbon dioxide).Components of an animal's mass balance Figure 6: Components of an animal's mass balance

This black-tailed deer consumes plant material rich in carbon but poor in other necessary nutrients, such as nitrogen (N). View Terms of Use Mass Balance in Watersheds Ecologists have often used naturally delineated ecosystems, such as lakes or watersheds, for applying mass balances. Mass migration of Mormon crickets (Anabrus simplex) in the American west Figure 7: Mass migration of Mormon crickets (Anabrus simplex) in the American west Researchers have shown that crickets are searching for protein and salt and keep moving forward to prevent becoming food for other hungry crickets. View Terms of Use The Hubbard Brook Experimental Forest in the White Mountains of New Hampshire, USA, has been the site of ecosystem mass balance studies since the 1960s. By installing V-notch weirs, investigators could precisely and continuously measure stream discharge. Mass Balance in Human-Dominated Ecosystems Mass balance constraints apply everywhere, even to highly altered ecosystems such as cities or agricultural fields. Ecologists can apply the law of conservation of mass to the analysis of elemental cycles by conducting a mass balance. Labels also indicate the length of time that the atom spends in each compartment. In mature forests, the amount of carbon taken up through photosynthesis may equal the amount of carbon respired by the forest ecosystem, so there is no net change in stored carbon over time. Ribonucleic acid (RNA) is the biomolecular template used in protein synthesis. Every compartment has inputs and outputs.