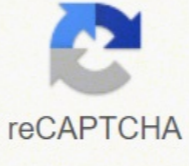




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JSTOR 1313224. [^] Vitt, L. doi:10.1038/35012221. ISBN 0-691-08436-X. The effect of global warming is already being registered in melting glaciers, melting mountain ice caps, and rising sea levels. 14 (1): 249–268. P.; Leemans, R.; Monserud, R. doi:10.1016/j.earsciev.2009.09.005. ISBN 978-0-8218-1152-8. [^] Krebs, J. "Metapopulation dynamics" (PDF). "Ecological Complexity in a Coffee Agroecosystem: Spatial Heterogeneity, Population Persistence and Biological Control". 9 (4): 296–306. G.; Rehner, S. doi:10.3390/md8030594. K. K.; Keller, L. [^] Cook, R. Emmett; Gonzalez, Andrew; Hooper, David U.; Perrings, Charles; Venail, Patrick; Narwani, Anita; Mace, Georgina M.; Tilman, David; Wardle, David A.; Kinzig, Ann P.; Dally, Gretchen C.; Loreau, Michel; Grace, James B.; Lavigne, Anne; Srivastava, Diane S.; Naeem, Shahid; Gonzalez, Andrew; Hooper, David U.; Perrings, Charles; Venail, Patrick; Narwani, Anita; Mace, Georgina M.; Tilman, David; Wardle, David A.; Kinzig, Ann P.; Dally, Gretchen C.; Loreau, Michel; Grace, James B.; Lavigne, Anne; Srivastava, Diane S.; Naeem, Shahid; Townsend, C. CiteSeerX 10.1.1.322.7255. (1866) Generale Morphologie der Organismen. Hypotheses are evaluated with reference to a null hypothesis which states that random processes create the observed data. A common, analogous model fixes the equilibrium, r/a (

{\displaystyle r/a}

), as k , which is known as the "carrying capacity." Population ecology builds upon these introductory models to further understand demographic processes in real study populations. (1970). doi:10.1016/j.ecocom.2003.09.001. "The role of habitat shift in the evolution of lizard morphology: Evidence from tropical Tropidurus". doi:10.1038/nature04514. S2CID 27553272. ISBN 978-0-9374779-0-0. Some species are adapted to forest fires, such as pine trees that open their cones only after fire exposure (right). PMID 21632377. [^] Heimann, Martin; Reichstein, Markus (2008). Journal of Biogeography. [JSTOR 3803199. 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[49] 18 Simplified population models usually start with four variables: death, birth, immigration, and emigration. Archived from the original (PDF) on 10 October 2008. Richards (1st ed.). [^] a b Scholes, R. doi:10.1038/426769a. [^] Shimela, J.; Jumars, P. S2CID 55279332. PMC 2486312. "Conveying the intellectual challenge of ecology: An historical perspective" (PDF). S.; Wilson, E. 378 (6558): 715–716. E.; Frederick, W. H.; Tipler, B.; Bohaty, S. doi:10.1038/35098000. [JSTOR 3881528. Academic Press. Synthese, N.; Jürgens, N.; Larigauderie, A.; Muchoney, D.; Walther, B. "Understanding and managing the global carbon cycle". For example, individual tree leaves respond rapidly to momentary changes in light intensity, CO2 concentration, and the like. doi:10.1023/B:VEGE.0000029380.04821.99. PMC 17873. Heat is a form of energy that regulates temperature. [^] Webb, J. PMC 2214820. (1974). "Nectar robbing: Ecological and evolutionary perspectives". p. 1. 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[^] Friedman, J.; Harder, L. 183 (3): 530–545. B.; Dunham, A. Biogeochemistry. University of Chicago Press. Food webs are a type of concept map or a heuristic device that is used to illustrate and study pathways of energy and material flows.[6] [69] [70] Food webs are often limited relative to the real world. Journal of Ethology. Other events, such as the evolution of trees and the colonization of land in the Devonian period played a significant role in the early development of ecological trophism in soils.[207] [210] [211] Biogeochemistry and climate Main article: Biogeochemistry See also: Nutrient cycle and Climate Ecologists study and measure nutrient budgets to understand how these materials are regulated, flow, and recycled through the environment.[108] [109] [168] This research has led to an understanding that there is global feedback between ecosystems and the physical parameters of this planet, including minerals, soil, pH, ions, water, and atmospheric gases. (1945). 6 (11): 990–995. Bibcode:1960Sci...131.1292H. Anaerobic soil microorganisms in aquatic environments use nitrate, manganese ions, ferric ions, sulfate, carbon dioxide, and some organic compounds; other microorganisms are facultative anaerobes and use oxygen during respiration when the soil becomes drier. Fragile Dominion: Complexity and the Commons. Earth Surface Processes and Landforms. "Social insect symbiosis: evolution in homeostatic fortresses" (PDF). Paleobiology. PMID 19887266. Stephen Forbes (1887)[228] Ernst Haeckel (left) and Eugenius Warming (right), two founders of ecology Ecological concepts such as food chains, population regulation, and productivity were first developed in the 1700s, through the published works of microscopist Antoni van Leeuwenhoek (1632–1723) and botanist Richard Bradley (1688?–1732).[4] Biogeographer Alexander von Humboldt (1769–1859) was an early pioneer in ecological thinking and was among the first to recognize ecological gradients, where species are replaced or altered in form along environmental gradients, such as a climate forming along a rise in elevation. doi:10.1093/beheco/arp152. On a planetary scale, ecosystems are affected by circulation patterns in the global trade winds. 8 (1): 27–38. J.; Bashey, F. "The niche concept: suggestions for its use in human ecology". 45 (3–4): 154–159. [^] a b c Stauffer, R. 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"Thermal effects of radiation and wind on a small bird and implications for microsite selection". 40 (2): 188–198. With consideration of the selection pressure on cognition, cognitive ecology can contribute intellectual coherence to the multidisciplinary study of cognition. "[128] [129] As a study involving the 'coupling' or interactions between organism and environment, cognitive ecology is closely related to enactivism.[127] a field based upon the view that "...we must see the organism and environment as bound together in reciprocal specification and selection...".[130] Social ecology Main article: Social ecology (academic field) Social-ecological behaviours are notable in the social insects, slime moulds, social spiders, human society, and naked mole-rats where eusocialism has evolved. Environmental Review. doi:10.1641/0006-3568(2006)0056[0203:TCOOAE]2.0.CO;2. doi:10.1111/(ISSN)1365-2699. [^] Gould, Stephen J.; Vrba, Elizabeth S. doi:10.1111/j.1469-8137.2009.02914.x. PMID 19552694. 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Prior to The Origin of Species, there was little appreciation or understanding of the dynamic and reciprocal relations between organisms, their adaptations, and the environment.[224] An exception is the 1789 publication Natural History of Selborne by Gilbert White (1720–1793), considered by some to be one of the earliest texts on ecology.[241] While Charles Darwin is mainly noted for his treatise on evolution,[242] he was one of the founders of soil ecology.[243] and he made note of the first ecological experiment in The Origin of Species.[239] Evolutionary theory changed the way that researchers approached the ecological sciences.[244] Since 1900 Modern ecology is a young science that first attracted substantial scientific attention toward the end of the 19th century (around the same time that evolutionary scientific interest). M.; Lugo, A. "Influences of architecture and wind pollination in six grass species" (PDF). Bulletin of the Ecological Society of America. 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The biotic environment includes genes, cells, organisms, members of the same species (conspecifics) and other species that share a habitat.[167] The distinction between external and internal environments, however, is an abstraction parsing life and environment into units or facts that are inseparable in reality. S2CID 155638387. Archived (PDF) from the original on 6 June 2011. 18 (6): 1670–1671. doi:10.1111/j.1461-0248.2006.00997.x. PMID 17257103. Oxford University Press. 440 (7081): 165–173. [^] Aguirre, A. doi:10.1046/j.1461-0248.2001.00218.x. [^] Irwin, Rebecca E.; Bronstein, Judith L.; Manson, Jessamyn S.; Richardson, Leif (2010). Annual Review of Ecology and Systematics. [^] Beyer, Hawthorne, L.; Haydon, Daniel T.; Morales, Juan M.; Frair, Jacqueline L.; Hebblewhite, Mark; Mitchell, Michael; Matthiopoulos, Jason (2010). Carbon dioxide, for example, is reduced to methane (CH4) by methanogenic bacteria.[178] The physiology of life is also specially adapted to compensate for environmental salt levels through osmoregulation. Bibcode:2010ESPL...35...78R. [^] Ceballos, G.; Ehrlich, P. Archived from the original on 5 December 2010. PMID 22318516. Archived (PDF) from the original on 21 September 2017. 283 (7): 641–652. doi:10.4319/lo.1995.40.5.0845. He will thus be made to see the impossibility of studying any form completely, out of relation to the other forms. – the necessity for taking a comprehensive survey of the whole as a condition to a satisfactory understanding of any part. doi:10.1086/284275. This is known as the dialectical approach to ecology in the pea aphid (Acyrthosiphon pisum) reared at different temperatures". The displays are driven by sexual selection as an advertisement of quality of traits among suitors.[126] Cognitive ecology Cognitive ecology integrates theory and observations from evolutionary ecology and neurobiology, primarily cognitive science, in order to understand the effect that animal interaction with their habitat has on their cognitive systems and how those systems restrict behavior within an ecological and evolutionary framework.[127] "Until recently, however, cognitive scientists have not paid sufficient attention to the fundamental fact that cognitive traits evolved under particular natural settings. "All wet or dried up? "An emerging synthesis between community ecology and evolutionary biology". This environmental process produces spatial divisions in biodiversity, as species adapted to wetter conditions are range-restricted to the coastal mountain valleys and unable to migrate across the xeric ecosystems (e.g., of the Columbia Basin in western North America) to intermix with sister lineages that are segregated to the interior mountain systems.[194] [195] Fire Main article: Fire ecology Forest fires modify the land by leaving behind an environmental mosaic that diversifies the landscape into different seral stages and habitats of varied quality (left). doi:10.1579/0044-7447(2007)36[639:CHANSJ]2.0.CO;2. S2CID 145482219. 327 (5962): 196–198. doi:10.2307/1929981. Research in community ecology might measure species diversity in grasslands in relation to soil fertility. R.; Burnham, K. Behaviours can evolve by means of natural selection as adaptive traits conferring functional utilities that increases reproductive fitness.[119] [120] Mutualism: Leafhoppers (Euymela fenestrata) are protected by ants (Tridymoxenus purpureus) in a mutualistic relationship. When soils are flooded, they quickly lose oxygen, becoming hypoxic and eventually completely anoxic where anaerobic bacteria thrive among the roots. A.; Hendrix, P. This means that higher-order patterns of a whole functional system, such as an ecosystem, cannot be predicted or understood by a simple summation of the parts.[103] "New properties emerge because the components interact, not because the basic nature of the components is changed".[4]: 8 Ecological studies are necessarily holistic to reductionistic.[35] [98] [104] Holism has three scientific meanings or uses that identify with ecology: 1) the mechanistic complexity of ecosystems, 2) the practical description of patterns in quantitative reductionist terms where correlations may be identified but nothing is understood about the causal relations without reference to the whole system, and 3) a metaphysical hierarchy whereby the causal relations of larger systems are understood without reference to the smaller parts. 19 (4): R575–R583. "The evolution of mutualists: exploring the paths between conflict and cooperation" (PDF). "On aims and methods of ethology" (PDF). S2CID 42979006. 121 (2): 205–230. Bibcode:2009Geodo.149..143P. [^] a b Folke, C.; Carpenter, S.; Walker, B.; Scheffer, M.; Elmqvist, T.; Gunderson, L.; Holling, C. S. (2004). PMID 21237927. C.; Freeman, K. Sink patches are unproductive sites that only receive migrants; the population at that site will disappear unless rescued by an adjacent source patch or environmental conditions become more favourable. Bibcode:1974Tel...26...2L. doi:10.1086/282798. 408 (6815): 965–967. Ecologists use a mixture of computer models and field studies to explain metapopulation structure.[61] [62] Community ecology Interspecific interactions such as predation are a key aspect of community ecology. For example, one population of a species of tropical lizard (Tropidurus hispidus) has a flattened body relative to the main populations that live in open savanna. [^] Etemad-Shahidi, A.; Imberger, J. 237 (1–2): 1–20. Archived (PDF) from the original on 9 June 2011. Bibcode:2000Natur...406..695P. [^] Meysman, F. M. doi:10.2307/3566073. [^] a b Wilkinson, M. In contrast, homeotherms regulate their internal body temperature by expending metabolic energy.[108] [109] [158] There is a relationship between light, primary production, and ecological energy budgets. Ecology. Archived from the original (PDF) on 30 December 2010. 413 (6856): 501–596. 40 (5): 845–859. It is the chief organizing centre of most ecosystem functions, and it is of critical importance in agricultural science and ecology. The birds-of-paradise, for example, sing and display elaborate ornaments during courtship. Biodiversity within ecosystems can be organized into trophic pyramids, in which the vertical dimension represents feeding relations that become further removed from the base of the food chain up toward top predators, and the horizontal dimension represents the abundance or biomass at each level.[80] When the relative abundance or biomass of each species is sorted into its respective trophic level, they naturally sort into a 'pyramid of numbers'.[81] Species are broadly categorized as autotrophs (or primary producers), heterotrophs (or consumers), and Detritivores (or decomposers). PLOS ONE. S2CID 4333920. "Holism and reductionism in evolutionary ecology". American Journal of Botany. Gregory, Gibbs, James P. S2CID 4425455. [^] Hawkins, B. S2CID 46962930. doi:10.1007/BF02356689. "The age of the Earth". These migration routes involved an expansion of the range as plant populations expanded from one area to another. "A history of the ecological sciences, part 23: Linnaeus and the economy of nature". Soil microorganisms are influenced by and are fed back into the trophic dynamics of the ecosystem. "Does population ecology have general laws?". (18 January 1996). 142 (3): 379–411. doi:10.1177/086026608321632. 449 (7164): 804–810. doi:10.1126/science.195.4284.1289. PMID 10468593. "Exaptation—a missing term in the science of form". Archived from the original on 18 June 2019. Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence. doi:10.1002/(SICI)097-010X(19990601)283:7<O.CO;2-W. "Haeckel, Darwin and ecology". G.; Fenichel, T.; Delong, E. Ecological Modelling. Fundamentals of Ecology. [^] Mason, H. doi:10.1007/s1120-005-8388-2. "Disturbance facilitates rapid range expansion of aspen into higher elevations of the Rocky Mountains under a warming climate". Ecology overlaps with the closely related sciences of biogeography, evolutionary biology, genetics, ethology, and natural history. The term has several interpretations, and there are many ways to index, measure, characterize, and represent its levels of decrease with decreasing pressure and are a limiting factor for life at higher altitudes. [183] Water transportation by plants is another important ecophysiological process affected by osmotic pressure gradients. [194] [185] [186] Water transportive levels.[12] [14] [15] Biodiversity plays an important role in ecosystem services which by definition maintain and improve human quality of life.[13] [16] [17] Conservation priorities and management techniques require different approaches and considerations to address the full ecological scope of biodiversity. 131 (3409): 1292–1297. [^] Scheffer, M.; Carpenter, S.; Foley, J. In Newtonian fashion, he brought a scientific exactitude for measurement into natural history and even alluded to concepts that are the foundation of a modern ecological law on species-to-area relationships.[229] [230] [231] Natural historians, such as Humboldt, James Hutton, and Jean-Baptiste Lamarck (among others) laid the foundations of the modern ecological sciences.[232] The term "ecology" (German: Oekologie, Ökologie) was coined by Ernst Haeckel in his book Generale Morphologie der Organismen (1866).[233] Haeckel was a zoologist, artist, writer, and later in life a professor of comparative anatomy.[222] [234] Opinions differ on who was the founder of modern ecological theory. United Nations. On the organismal scale, gravitational forces provide directional cues for plant and fungal growth (gravitropism), orientation cues for animal migrations, and influence the biomechanics and size of animals.[108] Ecological traits, such as allocation of biomass in trees during growth are subject to mechanical failure as gravitational forces influence the position and structure of branches and leaves.[180] The cardiovascular systems of animals are functionally adapted to overcome the pressure and gravitational forces that change according to the features of organisms (e.g., height, size, shape), their behaviour (e.g., diving, running, flying), and the habitat occupied (e.g., water, hot deserts, cold tundra).[181] Pressure climatic and osmotic pressure places physiological constraints on organisms, especially those that fly and respire at high altitudes, or dive to deep ocean depths.[182] These constraints influence vertical limits of ecosystems in the biosphere, as organisms are physiologically constrained by the inflorescence in grasses is subject to the physical stresses and shaped by the forces of natural selection facilitating wind-pollination (anemophily). [189] [190] Turbulent forces in air and water affect the environment and ecosystem distribution, form, and dynamics. H.; James, S.; Koeler, K. Archival from the original on 11 November 2015. J.; Snyder, W. M.; McGuire, A. 21 (3): 311–352. Some Mathematical Questions in Biology. 3 (2): 151–156. [^] Ives, A. doi:10.1126/science.1110063. B.; Clark, B. doi:10.1111/j.1748-7692.1995.tb00294.x. [^] Polis, G. [^] Eastwood, R. To be adapted to their environment and face predator threats, organisms must balance their energy budgets as they invest in different aspects of their life history, such as growth, feeding, mating, socializing, or modifying their habitat. Retrieved 28 January 2010. "Bistability of atmospheric oxygen and the Great Oxidation" (PDF). ISBN 0-7216-1120-6. R.; Ebach, M. 321 (5892): 1044–1045. B.; Guisan, A.; Broennimann, O.; Randin, C. [^] Hinchman, L. [^] May, R. doi:10.1890/07135. 38 (2): 325–340. Examples of mutualism include fungus-growing ants employing agricultural symbiosis, bacteria living in the guts of insects and other organisms, the fig wasp and yucca moth pollination complex, lichens with fungi and photosynthetic algae, and corals with photosynthetic algae.[134] [135] If there is a physical connection between host and associate, the relationship is called symbiosis. 43: 47–78. [^] Kastak, D.; Schusterman, R. 3 (2): 3–17. Termitite mounds, for example, maintain a constant internal temperature through the design of air-conditioning chimneys. doi:10.1029/1999GB900076. Systematic Zoology. Noss & Carpenter (1994) [10]: 5 Biodiversity (an abbreviation of "biological diversity") describes the diversity of life from genes to ecosystems and spans every level of biological organization. doi:10.1126/science.198.4312.22. doi:10.1111/j.1523-1739.2004.00107.x. [^] Loehle, C. (2009). 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ecology in a new sub-discipline called phyllogeny.[154] Human ecology Main article: Human ecology The history of life on Earth has been a history of interaction between living things and their surroundings. "Structure and function of lactate dehydrogenase from hagfish". JSTOR 186950. doi:10.1111/j.2153-3490.1974.tb01946.x. ^ a b c Lovelock, J. Retrieved 2 February 2010. S2CID 30340899. Wilson predicted in 1992 that the 21st century "will be the era of restoration in ecology"[162] Ecological science has boomed in the industrial investment of restoring ecosystems and their processes in abandoned sites after disturbances. President and Fellows of Harvard College. Scientific holism differs from mysticism that has appropriated the same term. Journal of the Acoustical Society of America. W. Lacey, E. 24: 587-619. Bibcode:2003Natur.424..303Y. The premise behind the r/K selection model is that natural selection pressures change according to population density. For example, their roots and stems contain large air spaces (aerenchyma) that regulate the efficient transportation of gases (for example, CO2 and O2) used in respiration and photosynthesis. Archived from the original (PDF) on 26 June 2010. "A history of the ecological sciences: early Greek origins" (PDF). "When is a trophic cascade a trophic cascade?" (PDF). doi:10.1126/science.131.3409.1292. doi:10.1086/285546. ^ Acot, P. ^ Brinson, M. 32 (3): 187-192. 94 (8): 3828-3832. Carson used ecological science to link the release of environmental toxins to human and ecosystem health. 405 (6783): 212-218. S2CID 30261494. The laws of thermodynamics, for example, apply to ecology by means of its physical state. The transition to an oxygen-dominant atmosphere (the Great Oxidation) did not begin until approximately 2.4-2.3 billion years ago, but photosynthetic processes started 0.3 to 1 billion years prior.[176][177] Radiation: heat, temperature and light The biology of life operates within a certain range of temperatures. 198 (4312): 22-26. In so doing they modify, maintain and create habitats. [39]: 373 The ecosystem engineering concept has stimulated a new appreciation for the influence that organisms have on the ecosystem and evolutionary process. Genes play an important role in the interplay of development and environmental expression of traits.[35] Resident species evolve traits that are fitted to the selection pressures of their local environment. Archived from the original (PDF) on 9 May 2013. P. 2005. Haeckel, who admired Darwin's work, defined ecology in reference to the economy of nature, which has led some to question whether ecology and the economy of nature are synonymous.[238] The layout of the first ecological experiment, carried out in a grass garden at Woburn Abbey in 1816, was noted by Charles Darwin in The Origin of Species. Molecular Ecology. doi:10.2307/1931693. A.; Shine, R. ^ Garren, K. Plants generally have the greatest biomass. doi:10.1007/BF02872506. M.; Potts, W. Retrieved 31 January 2010. doi:10.1002/esp.1912. Sociobiology: The New Synthesis (25th anniversary ed.). "Energy flow in ecosystems: A historical review". ^ a b c d e Korondy, E. S2CID 7311971. "The living Earth". 195 (3-4): 153-171. A.; Walker, B.; Walker, B. PMC 20526. London, UK: Sidgwick and Jackson. Chameleons change their skin colour to match their background as a behavioural defence mechanism and also use colour to communicate with other members of their species, such as dominant (left) versus submissive (right) patterns shown in the three species (A-C) above.[111] All organisms can exhibit behaviours. Bibcode:1961SciAm.204d.150C. S.; Hillebrand, H. In this way, the environmental and ecological relations are studied through reference to conceptually manageable and isolated material parts. Kluwer Academic Publishers. Journal of Ecological Research. ^ Pockman, W. ^ Berryman, A. S2CID 23760946. Inquiry. ^ Thompson, R. S2CID 4404849. doi:10.1038/nature06591. Human Ecology Review. Bibcode:2000GBioC.14..249L. doi:10.1016/S0160-9327(00)01369-7. 320 (5879): 1034-1039. "Successive replacement of tending ant species at aggregations of scale insects (Hemiptera: Margarodidae and Ericoccidae) on Eucalyptus in south-east Queensland" (PDF). 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Natural capital that supports populations is critical for maintaining ecosystem services[18][19] and species migration (e.g., riverine fish runs and avian insect control) has been implicated as one mechanism by which those species losses are experienced.[20] An understanding of biodiversity has practical applications for species and ecosystem-level conservation planners as they make management recommendations to consulting firms, governments, and industry.[21] Habitat Main article: Habitat Biodiversity of a coral reef. doi:10.4067/50716-976020030001000008. "Experimental ecology of food webs: Complex systems in temporary ponds" (PDF). 18 (6): 851-860. Jones (1994). doi:10.2307/131224. This provides growing conditions for future generations and forms a habitat for many other species.[22] Long-tailed broadbill building its nest The habitat of a species describes the environment over which a species is known to occur and the type of community that is formed as a result.[23] More specifically, "habitats can be defined as regions in environmental space that are composed of multiple dimensions, each representing a biotic or abiotic environmental variable; that is, any component or characteristic of the environment related directly (e.g. forage biomass and quality) or indirectly (e.g. elevation) to the use of a location by the animal." [24]: 745 For example, a habitat might be an aquatic or terrestrial environment that can be further categorized as a montane or alpine ecosystem. S2CID 85371147. In recognition of these functions and the incapability of traditional economic valuation methods to see the value in ecosystems, there has been a surge of interest in social-natural capital, which provides the means to put a value on the stock and use of information and materials stemming from ecosystem goods and services. "Reid's paradox of rapid plant migration" (PDF). 94 (1): 17-26. "Vernadsky's biosphere concept: an historical perspective". The scientist Ellen Swallow Richards may have first introduced the term "oekology" (which eventually morphed into home economics) in the U.S. as early as 1892.[245] In the early 20th century, ecology transitioned from a more descriptive form of natural history to a more analytical form of scientific natural history.[229][232] Frederic Clements published the first American ecology book in 1905,[246] presenting the idea of plant communities as a superorganism. Bibcode:2010Sci...327..196K. Retrieved 12 April 2020. 15 (6): 1419-1439. 365 (1550): 2245-2254. ^ Boucher, D. This perceptual shift placed the focus back onto the life histories of individual organisms and how this relates to the development of community associations.[248] The Clementsian superorganism theory was an overextended application of an idealistic form of holism.[35][105] The term "holism" was coined in 1926 by Jan Christiaan Smuts, a South African general and polarizing historical figure who was inspired by Clements' superorganism concept.[249][C] Around the same time, Charles Elton pioneered the concept of food chains in his classical book Animal Ecology.[81] Elton[11] defined ecological relations using concepts of food chains, food cycles, and food size, and described numerical relations among different functional groups and their relative abundance. Earth-Science Reviews. D.; Stroock, A. PMID 21232425. The Clementsian paradigm was challenged by Henry Gleason,[247] who stated that ecological communities develop from the unique and coincidental association of individual organisms. CiteSeerX 10.1.1.401.777. Bibcode:1997PNAS...94.3828V. "Managing for ocean biodiversity to sustain marine ecosystem services" (PDF). These early phases of population growth experience density-independent forces of natural selection, which is called r-selection. In the case of all things which have several parts and in which the totality is not, as it were, a mere heap, but the whole is something besides the parts, there is a cause; for even in bodies contact is the cause of unity in some cases and in others viscosity or some other such quality." References ^ Stadler, B.; Michalzik, B.; Müller, T. PMID 14685210. hdl:1808/13308. "Coupled human and natural systems" (PDF). The Background of Ecology: Concept and Theory. ^ Ulanowicz, R. Archived from the original (PDF) on 20 August 2011. Bibcode:2005Sci...309..600P. (1983). S2CID 29793247. ISBN 978-0-12-554720-8. Boston: Whitcomb & Barrows. doi:10.2307/3803199. J.; Mace, G. "Ecosystem engineering in space and time". For example, trees living in the equatorial regions of the planet supply oxygen into the atmosphere that sustains species living in distant polar regions of the planet. "Soils as extended composite phenotypes". Archived from the original (PDF) on 9 August 2011. ISBN 978-0-7382-0493-2. The whole of the planet's soil ecosystems is called the pedosphere where a large biomass of the Earth's biodiversity organizes into trophic levels. Some species (e.g., *Pinus halepensis*) cannot germinate until after their seeds have lived through a fire or been exposed to certain compounds from smoke. 289 (5488): 2279. New Phytologist. Archived from the original (PDF) on 19 May 2011. doi:10.1146/annurev.ecolsys.35.112202.130116. Plants, for example, are equipped with a variety of adaptations to deal with forest fires. 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