Niche

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The niche is an abstract concept that describes the ecological space that a species occupies. A species' niche is determined by the environmental conditions it inhabits, the resources it uses, and its interactions with other species.

The niche has been a fundamental concept in ecological theory for almost a century. It was first developed by American zoologist Joseph Grinnell and English zoologist Charles S. Elton (Griesemer 1992), although components of the niche concept appeared in the writings of Darwin, Wallace, and other early naturalists (Vandermeer 1972). Grinnell and Elton had distinct conceptions of the niche and applied the term differently, but by the middle of the twentieth century most ecological textbooks blended their views into a single, rather vague idea that the niche described an organism's ecological role in the community. The niche concept was formalized in 1957 by the British-born ecologist G. Evelyn Hutchinson as a multidimensional space, an "n-dimensional hyper volume," whose dimensions describe all of the biotic and abiotic factors influencing an organism (Hutchinson 1957). The dimensions describing an organism's niche may include factors such as temperature, rainfall, altitude, seasonality, and food availability; although a volume of more than three dimensions is difficult to visualize, it provides a useful abstract description of the conditions necessary for a species to maintain a viable population. Hutchinson's rigorous, formal definition revolutionized niche theory and is the basis of the modern niche concept. This concept has been further developed, mathematically specified, and empirically examined in the decades since by ecologists Colwell, Lawton, Levins, MacArthur, Roughgarden, Schoener, and others.

Hutchinson's geometric abstraction of the niche describes the full set of conditions in which a species can survive and persist, its "fundamental niche." In nature, species do not occupy the full range of abiotic conditions that could support them, because interactions with other species (e.g., competition, predation) restrict them to a subset of their fundamental niche. The range of conditions actually occupied by a species is known as its "realized niche."

The niche concept is central to community ecology. Classical ecological theory postulates that no two species can occupy precisely the same niche under constant ecological conditions, an idea known as the "competitive exclusion principle" or "Gause's theorem," after the Russian mathematical ecologist Georgii F. Gause, whose work brought the concept to widespread attention. According to this perspective, interspecific competition fundamentally structures ecological communities; if two species occupied the same niche, the inferior competitor would either be driven extinct or evolve to occupy a different niche. Therefore, according to niche theory, communities are composed of sympatric species that utilize resources in sufficiently distinct ways to permit coexistence. For example, the diets of sympatric primate species tend to diverge during periods of resource scarcity, as species fall back on resources that are not consumed by other taxa. Although diet and body size (a proxy for diet) are generally considered to be the primary axes of niche differentiation among primates, differences in habitat selection, activity patterns, and canopy use may also permit coexistence. The competitive exclusion principle is widely accepted by ecologists, although it is often difficult to empirically demonstrate the process of interspecific competition in wild species, and observed patterns of niche differentiation may be due to processes other than interspecific competition.

The unified neutral theory of biodiversity provides an alternative explanation for the structure of ecological communities (Hubbell 2001). According to neutral theory, differences among individuals are assumed to have no effect on fitness, and community composition is largely determined by random effects. Neutral theory predicts that the species composition of a community is governed by its

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size, speciation rate, and dispersal rate, and will change stochastically over time. MacArthur and Wilson's famous model of island biogeography is an example of a neutral model; it predicts the expected equilibrium number of species on islands remarkably well, based on island size and the distance from the mainland. There has been little work applying neutral theory to primate communities, although recent macroecological work indicates that continental and regional patterns of primate community composition are consistent with predictions of neutral theory. For example, several studies have indicated that primate communities are importantly structured by dispersal limitation, a key component of neutral models.

Although the niche concept and neutral theory are frequently presented as alternative explanations for observed patterns in biodiversity, they need not be viewed as mutually exclusive. Just as the genetic structure of a population is influenced by both natural selection and genetic drift, the ecological structure of a community can be affected by both interspecific competition and ecological drift. Indeed, most studies indicate that primate communities are influenced by both.

The utility of the niche as an ecological concept has been hotly debated for decades, and its popularity has waxed and waned over time. The niche concept nevertheless remains a central component of most branches of modern ecology, including biogeography, community ecology, macroecology, physiological ecology, and population biology. Recent applications of the concept include: *species distribution modeling*, a widely applied set of tools used to predict the probability of species occurrence, describe spatial variation in fitness, and forecast the responses of species to global climate change; the *niche construction* concept, which examines how species alter their environment, thereby altering their own niches; and consideration of phylogenetic *niche conservatism* at different taxonomic levels.

SEE ALSO: Ecological Communities; Habitat Use; Niche Partitioning

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FURTHER READING

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