Accounting for tree height, biodiversity is 3-D

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Roberto Cazzolla Gatti, Ph.D., is an Associate Professor at Biological Institute of the Tomsk State University (Russia). Credit: TSU

The species-area relationship (SAC) is a long-term pattern in ecology and is discussed in most academic Ecology books. Its implications are

relevant for many ecological, evolutionary, conservation and biogeographic purposes. Conversely, the associated volume-species relationship has been mostly ignored. According to a new study published in the journal *Plant Ecology*, this relationship may play a fundamental ecological role, and it is relevant for many ecological applications such as the estimation of minimum viable populations, species ranges and protected areas. In this global-scale study, Roberto Cazzolla Gatti, Ph.D., Associate Professor at the Biological Institute of the Tomsk State University (Russia) and his Italian colleagues from the Euro-Mediterranean Center on Climate Change (CMCC) in Viterbo, investigated this new perspective looking at canopy height as a proxy of ecosystem volume ("biospace"), which influences plant richness in forest ecosystems.

Some decades ago, the Italian forest ecologist Lucio Susmel developed the idea of biospace, writing that "the features of multi-aged forests are a function of the aboveground biospace, modified by plants and animals living in a physical environment." The Italian ecologist suggested that "[Biospace may be defined as a] protected space within which it is possible to play all physiological, biological and evolutionary processes of a community [...] the parameter most appropriate for assessing biospace is the volume of the system that can be measured by the average height of the dominant trees."

The difficulty of detecting a tree's height from the ground and the lack of a comprehensive global flora census has impeded the definition of a general pattern of forest ecosystem volume and species diversity. Recent technological developments such as light detection and ranging (LiDAR) allow mapping forest vertical structure globally. Together with the availability of accurate botanical data, such as the NASA Canopy Height Global Map, which is combines satellite technology with field analyses, this opens incredible opportunities in ecology. Prof. Roberto Cazzolla Gatti says, "We investigated a possible global relation between species

richness and canopy height by comparing the high resolution Global Map of Canopy Height provided by NASA with the Plant Diversity Map produced by Barthlott and colleagues in 2007."

The results of this study showed that higher canopies account for more plant species—canopies represent a third dimension fully exploitable by these species. This is because larger volumes can contain larger numbers of species, but it is not only a matter of the available space.

Gatti says, "I came across this idea working for many years in tropical, temperate and boreal forests. I wondered why higher canopies are almost always positively associated with higher levels of biodiversity. If the reason were only the climate, which is able to increase both tree height and biodiversity, we would have found within the same climatic strip around the world similar levels of diversity in forests with different canopy heights. This wasn't the case. Although climatic conditions are the same, biodiversity increases when canopies rise."

The study suggest that this positive correlation between biodiversity and canopy height is due to the increased biospace. The larger the volume of a forest ecosystem, the more layers and ecological conditions that diversify the environment, including light, humidity, food resources, water availability, climbing opportunity for lianas, presence of epiphytes, ferns and others. This also offers empirical proof to the recent hypotheses developed by Prof. Cazzolla Gatti about the emergence of new biodiversity-related niches, i.e. the idea that biodiversity begets biodiversity.

The relationship between biodiversity and canopy height is particularly evident in tropical regions. In fact, according to the latitudinal gradient theory, tropical rainforests are, on average, taller than temperate ones, and therefore offer more space for physiological, biological and evolutionary processes of the community. This feature allows species

with distinct traits to coexist and begets the emergence of new niches that increase the richness of a more stratified ecosystem.

However, because both climatic and latitudinal gradients correlate with forest height and diversity, Cazzolla Gatti and colleagues disentangled their hypothesis of a pure canopy height-diversity relation by analysing it within different macroclimate zones according to the Koppen-Geiger climate classification. This classification reflects a latitudinal zonation and removes the climatic influence from the canopy height-diversity relationship. However, the relationship was observed in each of the three main climate zones and this confirmed that canopy height influences species diversity irrespective of other factors such as precipitation and temperature (i.e. climate).

Roberto Cazzolla Gatti says, "The relation between canopy height and biodiversity has been poorly considered to date, even though it plays a significant role in ecology. Indeed, the vertical dimension of ecosystems, as a proxy of the biospace, should be considered together with the well-known species-area relationship. Moreover, the relation we discovered is fundamental for setting protected area extensions, when the bi-dimensional available environment should not be considered alone, but associated with the three-dimensional ecological volume. In this era of climatic changes and anthropogenic pressures, high numbers of species are exposed to extinction risk. Under the urgent need of species conservation and climate mitigation, 3-D is not only a fun or an innovative technological approach, but a new way to look at the natural dynamics to better plan the study and protection of ecosystems."

More information: Roberto Cazzolla Gatti et al, Exploring the relationship between canopy height and terrestrial plant diversity, *Plant Ecology* (2017). DOI: 10.1007/s11258-017-0738-6