EDITORIAL

# A Humboldtian view of mountains

In the early 19th century, when naturalists were busy cataloging Earth's inventory and separating the living world into labeled units, a 32-year-old explorer at the flanks of Chimborazo mountain in Ecuador—higher than anybody else had climbed by that time—saw the fog clearing, revealing an arena of tropical mountain life. According to his notes, this was the moment when Alexander von Humboldt coined the central paradigm of his scientific legacy: Everything is connected. Removing one factor or item will inevitably affect others. For Humboldt, born 250 years ago, life on Earth was a web of interactions. He was seeking generality and came up with an ecological theory in modern terms—one that has never ceased to be relevant.

Humboldt was the first to note that life on mountains is not driven by elevation as such, but by the climate associated with elevation. He introduced the concept of the isotherm—a line connecting elevations of equal temperature—to link mountains of the Arctic, the Alps, and the Andean Chimborazo by treeline position: at sea level in the Arctic and rising to 4000-m elevation near the equator, with all climatic life zones rising in parallel. Indeed, modern data show that the global treeline follows a Humboldtian isotherm of a 6°C mean temperature for the growing season. The treeline isotherm became the best known and best explained biogeographic boundary on Earth, defining the low-temperature limit of tree growth, even when trees are absent locally because of logging or fire. Thus, Humboldt's idea of linking the world's mountains by isotherms represented a breakthrough scientific concept.

Humboldt also was the first to describe one of the most powerful "experiments" by nature—steep elevation gradients that compress life zones into 4 to 5 km of elevation, which would otherwise be separated by thousands of kilometers of latitude near sea level. Not surprisingly, by lumping contrasting climates onto a single slope, mountains became hosts for more diverse life than any other terrestrial system. Not only do mountains harbor a high concentration of endemic species in specific regions, but their ruggedness also creates contrasting exposure to sun and wind. The result is a myriad of different local niches for life, which explains why mountain ecosystems are so rich in biodiversity. And thanks to the tremendous diversity of local life conditions, mountains have always offered refugia for plants and animals. However, these biota are vulnerable to anthropogenic drivers of change, from agriculture and forestry to extractive practices and pollution.

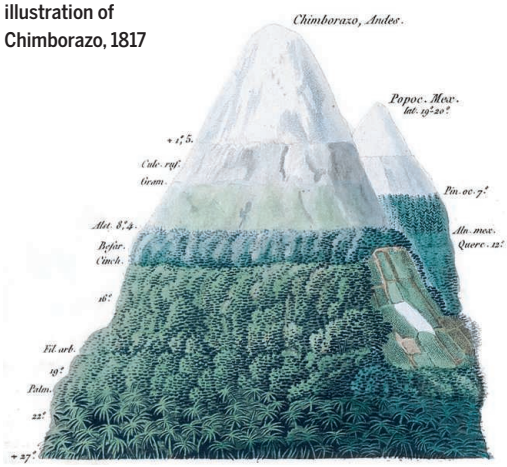
Excluding lowland hill country, mountains cover 12.5% of Earth's terrestrial surface outside of Antarctica and are inhabited by about half a billion people. This is where vulnerability comes into play: Through the forces of gravity, these populations live under the threat of floods, avalanches, and landslides. Another 3 billion people living in the forelands are influenced by mountains through the resources that they provide—water in particular—but also by the constraints that they impose, such as transport barriers.

Assessing, explaining, and caring for mountain biodiversity is the task of the Global Mountain Biodiversity Assessment (GMBA, hosted by Switzerland), a network now celebrating its 20th anniversary. GMBA has assembled a global mountain region inventory, with a climate-based delineation of life zones linked to the Humboldtian isotherms. GMBA's mountain portal combines this information with biodiversity data, and thus provides a scientific infrastructure for conservation planning and international mountain policy.

The unifying concept of climatic belts, with their specific flora and fauna and conditions for sustaining human life, across the globe, is Humboldt's legacy to modern mountain science. Scientific evidence across disciplines—from climatology to biology to social sciences and humanities—is showing how correct Humboldt was. Everything is connected. Our thinking and actions need to reflect this.

**–Christian Körner and Eva Spehn**

Humboldt's illustration of Chimborazo, 1817




***"Scientific evidence... is showing how correct Humboldt was. Everything is connected."***


**Christian Körner** *is a professor emeritus in the Department of Environmental Sciences at the University of Basel, Basel, Switzerland. ch.koerner@unibas.ch*

**Eva Spehn** *is a scientific coordinator at the Swiss Academy of Natural Sciences and the Institute of Plant Ecology of the University of Bern, Bern, Switzerland. eva.spehn@scnat.ch*


Downloaded from http://science.sciencemag.org/ on September 16, 2019

ILLUSTRATION: ALEXANDER VON HUMBOLDT/LIBRARY OF CONGRESS

10.1126/science.aaz4161



Published by AAAS

Science

# A Humboldtian view of mountains

Christian Körner and Eva Spehn

*Science* **365** (6458), 1061.
DOI: 10.1126/science.aaz4161

**ARTICLE TOOLS**
http://science.sciencemag.org/content/365/6458/1061

**RELATED CONTENT**
http://science.sciencemag.org/content/sci/365/6458/1092.full
http://science.sciencemag.org/content/sci/365/6458/1094.full
http://science.sciencemag.org/content/sci/365/6458/1098.full
http://science.sciencemag.org/content/sci/365/6458/1104.full
http://science.sciencemag.org/content/sci/365/6458/1108.full
http://science.sciencemag.org/content/sci/365/6458/1114.full
http://science.sciencemag.org/content/sci/365/6458/1119.full
http://science.sciencemag.org/content/sci/365/6458/1124.full
http://science.sciencemag.org/content/sci/365/6458/1074.full
http://science.sciencemag.org/content/sci/365/6458/1084.full
http://science.sciencemag.org/content/sci/365/6458/1088.full

**PERMISSIONS**
http://www.sciencemag.org/help/reprints-and-permissions

Use of this article is subject to the Terms of Service

*Science* (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science* is a registered trademark of AAAS.

Copyright © 2019 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works

Downloaded from http://science.sciencemag.org/ on September 16, 2019