Environment & Society Portal

From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories

Rozzi, Ricardo, Carolina Castro Jorquera, Luis Chavarría, Shaun Russell, Bernard Goffinet, Miguel Garcia, Kelli Moses, Tamara Contador, Francisca Massardo, Bruno Leibundgut, Teresa Paneque Carreño, Alain Smette, Itziar de Gregorio-Monsalvo, and Alejandra Tauro

Chile is a land drawn with the rhythm of nature itself. It is a natural laboratory that invites us to look up into the macrocosm and down into the microcosm. At both extremes of this long and narrow country, science activities have a major global impact. Today, over 50 percent of the world's astronomical observations use the telescopes of the European Southern Observatory (ESO) and other institutions installed in the Atacama Desert in northern Chile. Complementarily, at its southern end Chile established the Cape Horn International Center for Global Change Studies and Biocultural Conservation (CHIC) to investigate the microcosms, from the largest organism, planet Earth, to the smallest ones. CHIC explores diverse forms of knowledge and values to understand and protect the biosphere in the context of global socio-environmental change. This virtual exhibition enhances the integration of the sciences, arts, and humanities through a novel partnership with the Rachel Carson Center for Environment and Society, inviting visitors to be enchanted across the multiple scales of the cosmos.

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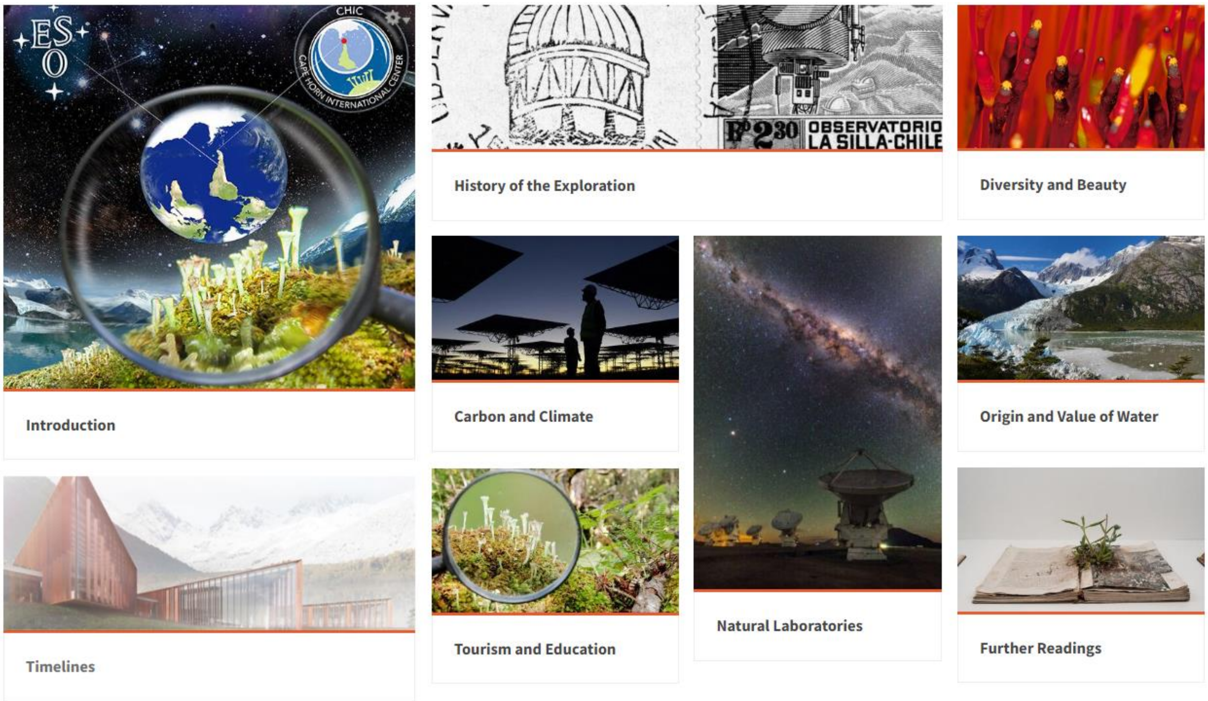

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About the Exhibition

Since the mid-twentieth century, astronomical observatories have been established in northern Chile to explore outer space. Since the beginning of the twenty-first century, the Cape Horn International Center (CHIC) has been established at the southern end of Chile to survey the responses of subantarctic biodiversity to climate change. Led by the University of Magallanes in Chile and the University of North Texas in the United States, in collaboration with other research and government institutions, CHIC has developed a long-term biocultural research, education, and conservation program to understand, value, and protect biological and cultural diversity. With the support of the government of the Region de Magallanes y Antártica Chilena, in 2022 CHIC inaugurated—a state-of-the-art research and education facility, located in Puerto Williams, capital city of the Provincia Antártica Chilena.

This virtual exhibition presents for the first time the complementarity of the astronomical and biocultural research conducted at the extreme ends of Chile. The world's clearest skies above the Atacama Desert and the planet's cleanest waters and ecosystems in the Cape Horn Biosphere Reserve (CHBR) offer unique opportunities for exploring the cosmos, from supernovae and constellations to tiny organisms. The examination of biophysical dimensions discloses surprising similarities between structures and patterns of galaxies and rocks, rivers, and organisms, including humans on Earth. This research invites us to appreciate the beauty of the cosmos and ponder our life habits in order to foster responsible ways of coexisting with diverse human and other-than-human inhabitants.

Artistic rendition of CHIC's multiple-scale exploration. (1) The local scale is depicted by the small hand lens with CHIC's new research, education, and conservation facility located in Puerto Williams, Chile, which consolidates two decades of active international, interdisciplinary, long-term collaborative partnerships. (2) The regional scale is illustrated by the inverted globe that indicates Cape Horn's unique geographical location as the "southern summit of the Americas," which offers an ideal (and still understudied) region to research and monitor global climate change. (3) The global scale represented by the large hand lens that symbolizes CHIC's research approach integrating natural and social sciences, humanities, education and ethics to appreciate multiple dimensions of the microcosm and macrocosm. The southern cross-constellation is an invitation to incorporate perspectives from both hemispheres, the South and the North, to address the complex challenges of social-environmental change.

Image by CHIC.

Acknowledgements

We are grateful for the intellectual and institutional support provided by the Rachel Carson Center (RCC), European Southern Observatories (ESO), Cape Horn International Center (CHIC), University of Magallanes (UMAG), and the University of North Texas (UNT).

This virtual exhibition was first envisioned in August 2021 at the RCC in Munich, during the workshop "From Hand-Lenses to Telescopes: Exploring the Micro- and Macro-Cosmos" convened by Prof. Dr. Christof Mauch (RCC director), Matias Undurraga Abott (general consul of Chile in Munich, 2018-2022), Prof. Dr. Xavier Barcons (director general of ESO, Munich), and Dr. Ricardo Rozzi (CHIC director, and professor at the University of North Texas, US, and the University of Magallanes, Chile).

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The 2021 workshop at the RCC included presentations by Dr. Martín Fonck (graduated from RCC and Ludwig-Maximilians-Universität Munich, Germany), Dr. Kurt Jax (Department of Conservation Biology, Helmholtz Centre for Environmental Research–UFZ, Leipzig, Germany), Teresa Paneque (astronomer, University of Chile and ESO), Dr. Christian Printzen (head of Cryptogams section, Senckenberg Natural History Museum, Frankfurt, Germany), and Dr. Laura Sánchez (CHIC and University of Magallanes, Chile).

We would like to express our special thanks to Pauline Kargruber, Jonatan Palmblad ("Jonte"), Andreas Jünger, and the whole RCC team as well as Monica Araus, Rolando Martínez, Paulina Llanos, Jennifer Torres, and the Omora Park interdisciplinary research team at CHIC. Ricardo Rozzi expresses his appreciation for the opportunity to come to the RCC and the valuable experience as a Carson Fellow in May–August 2021.

This exhibition was partially funded by the initiative Subantarctic Lichens, a New Sentinel of Global Climate Change: First International Course and Virtual Herbarium of High Latitude Cryptogams (ANID-FOVI210059, granted in 2021 to Omora Foundation in collaboration with CHIC, UMAG, and the University of Talca, Chile, and by CHIC–ANID/BASAL (FB210018), Chile.

The Authors

Ricardo Rozzi is a Chilean ecologist and philosopher. Rozzi is a professor at the University of North Texas in the United States and at the University of Magallanes in Chile, where he is director of the Cape Horn International Center (CHIC). He has coined three interrelated terms: "biocultural conservation," "biocultural homogenization," and "biocultural ethics." The latter values the vital links between the lifestyles of coinhabitants who share a common habitat. He led the establishment of the UNESCO Cape Horn Biosphere Reserve (2005) and the Diego Ramírez Islands–Drake Passage Marine Park (2019). He also first introduced the "field environmental philosophy" methodology for biocultural education, generating innovations in special-interest tourism themes and activities, such as "Ecotourism with a Hand Lens." You can learn more about his work here.

Carolina Castro Jorquera is a Chilean art historian and curator. She currently works as a guest lecturer in the MFA program "Research and Image Making" at Finis Terrae University in Santiago. Her book, *Camino de la conciencia: Mira Schendel, Víctor Grippo y Cecilia Vicuña* (The Way of Consciousness: Mira Schendel, Víctor Grippo and Cecilia Vicuña), was published by Ediciones Universidad Finis Terrae in 2020. As a curator, she has organized numerous exhibitions across the Americas and Europe. Carolina holds an MA in contemporary art and visual culture from the Museo Nacional Centro de Arte Reina Sofía and a PhD in art history from Autonomous University of Madrid. You can learn more about her work here.

Shaun Russell is an environmental scientist with 45 years of experience as a teacher and researcher in biodiversity conservation and protected-area management around the world. He held lecturing posts in Britain and South Africa and was formerly dean of the Science Faculty at the University of Namibia. He also worked for the British and South African Antarctic programs. Dr. Russell is currently the director of the Treborth Botanic Garden at Bangor University in Wales, and over the past 20 years he has applied his specialist knowledge of mosses and lichens to habitat conservation in the far south of Chile.

Bernard Goffinet is a professor in ecology and evolutionary biology at the University of Connecticut. His research interests focus on the diversity and evolution of mosses and lichens based on field work in the Americas, Asia, and Africa. He also engages in enhancing awareness of these lesser-known organisms through walks, books, and exhibits. He completed his BS and MS at the University of Liège, with a thesis focused on epiphytes in old growth forests, and earned his PhD at the University of Alberta for his study on the evolution of mosses. He has edited and written several books and is currently the president of the International Association of Bryologists. You can learn more about his work here.

Kelli Moses is the international coordinator of the Cape Horn International Center and the Sub-Antarctic Biocultural Conservation Program for the University of Magallanes. Ms. Moses has a bachelor's degree in biology and a master's degree in environmental sciences from the University of North Texas. She has held various roles with the Sub-Antarctic Biocultural Conservation Program both in the United States and Chile since 2005 and with the Cape Horn International Center since 2022. She coordinates international visits to the Omora Ethnobotanical Park, field courses and student research experiences, and the editorial line on biocultural conservation of the program.

Tamara Contador is a professor and researcher at the University of Magallanes in Chile. She is a researcher at the Cape Horn International Center (CHIC), at the Millennium Institute for Biodiversity of Antarctic and Subantarctic Ecosystems (BASE), and at the Millennium Nucleus of Invasive Salmonids (INVASAL). Her research focuses onnadaptations of terrestrial and freshwater invertebrates to climate change, particularly in subantarctic and antarctic ecosystems. She works at Omora Park in Navarino Island, where she seeks to promote the integration of environmental ethics and ecological sciences to contribute to biocultural conservation in freshwater ecosystems. You can learn more about her work here.

Francisca Massardo is a professor at the University of Magallanes (UMAG), Chile. She is an agronomist, holds an MS and a PhD in plant physiology from the University of Chile, and is a postdoctoral fellow in biocultural conservation at the University of Connecticut, US. Since 2000 she has led conservation efforts: the creation of the Omora Ethnobotanical Park, the Omora Foundation, and the Cape Horn Sub-Antarctic Center. She is also the chief editor of the Sub-Antarctic Biocultural Conservation Program at UMAG, and principal investigator of the Cape Horn International Center (CHIC). She has integrated basic and applied science for conservation with focus on the UNESCO Cape Horn Biosphere Reserve, Chile. You can learn more about her work here.

Miguel Garcia Corrales is a professional and academic with more than 20 years of experience in the development of studies and projects related to landscape, heritage, environmental evaluation of projects, and sustainable tourism, with a focus on Latin America. His research and projects have focused on the study of the natural and cultural landscape as fundamental assets for the endogenous development of sustainable tourism. For 10 years he has been an associate professor at the School of Architecture and Landscape, Central University of Chile, project director at the Institute of Tourist Heritage, Central University of Chile, and since 2023 he has been responsible for the tourism area of the Cape Horn International Center (Basal-ANID) led by the University of Magallanes.

Alejandra Tauro is an Argentinean biologist who works at El Colegio de Puebla, at the National Science and Technology Council, Mexico, and at the Cape Horn International Center (CHIC), Chile. She graduated as a biologist and professor of biology at the National University of Córdoba, Argentina. She obtained a master's degree and a doctorate in sciences from the National Autonomous University of Mexico, and a master's degree in sustainable development from the University of Lanús / FLACAM-CEPA, Argentina. Her research focuses on ecology and conservation biology, incorporating a biocultural perspective and inter- and transdisciplinary methodologies to address the heterogeneity of links between human well-being and nature. Tauro has worked at the interface between academia and civil society organizations, contributing to biocultural conservation practices that foster community and inter-actor collaboration.

Luis Chavarría holds a BS and a PhD in science with a major in astronomy from the University of Chile. He carried out his doctoral-thesis research at the Harvard-Smithsonian Center for Astrophysics and has done postdoctoral studies in Chile, France, and Spain, focusing on projects related to the star-formation process. In 2013 he joined the National Agency for Research and Development (ANID) as support astronomer and Chilean coordinator for the APEX (Atacama Pathfinder Experiment) telescope. In 2016 he became the director of the Astronomy Program, coordinating strategies to strengthen international collaboration and support the immense and growing scientific infrastructure installed in Chile to the benefit of the local scientific community. In 2021 he joined the European Southern Observatory (ESO) as the ESO representative in Chile. He became the first Chilean citizen to fill this position in the 60 years of ESO.

Bruno Leibundgut's career as an astrophysicist spans more than 30 years. His scientific contributions range from the nucleosynthesis in stellar explosions to the evolution of the universe. After completing his PhD at the University of Basel, Switzerland, he held positions as junior researcher at Harvard University in Cambridge, MA, and the University of California, Berkeley. For nearly 30 years he has been an astrophysicist at the European Southern Observatory (ESO). He held various positions within this intergovernmental organization, among them director for science. Bruno Leibundgut is deeply involved in the operations of large telescopes and currently serves as program scientist of the Very Large Telescope (VLT). Since 2012 he has also held an honorary professorship at the Technical University of Munich.

Teresa Paneque Carreño has an MS in astronomy and is currently a doctoral candidate at the European Southern Observatory, through the International Max Planck Research School program, and at the University of Leiden. She is also a topselling author of the multivolume children's books *El Universo Segun Carlota* (2021–2023) and does astronomy outreach through social media (@terepaneque). Her scientific interests revolve around planet-formation processes and the distribution and abundance of molecules in protoplanetary disks.

Alain Smette is an operations staff astronomer at the European Southern Observatory since 2004. He received his PhD from the Universite de Liège, Belgium, in 1994. After a postdoc at the Kapteyn Astronomical Institute, Groningen, he became a research associate at NASA's Goddard Space Flight Center, then returned to Liège in 2001. His research interests include the study of absorption lines in the spectra of quasars and gamma ray burst optical afterglows, gravitational lensing, and active galactic nuclei. As a member of the Science Operations department at Paranal, he was successively the instrument scientist for the VISIR then CRIRES instruments, and instrument operations team coordinator. He is currently a system scientist in the system engineering group at the Paranal Observatory.

Itziar de Gregorio-Monsalvo is an astrophysicist at the European Southern Observatory (ESO) in Chile, where she acts as head of the Office for Science and as faculty chair. Before, she was the head of the Atacama Large Millimeter Array Program management group. She did her PhD at the Spanish National Institute for Aerospace Technology, using the NASA Deep Space Network antennas to perform star-formation studies at centimeter wavelengths. She joined ESO in 2006 as an ESO ALMA fellow with duties at the Atacama Pathfinder Experiment (APEX) telescope, the Atacama Test Facility in Socorro, New Mexico, and the Operations Support Facilities near San Pedro de Atacama, in Chile. Her research focuses on stars, brown dwarfs, and planet formation

Introduction: Making the Invisible Visible in the Natural Laboratories of Chile's Extreme Zones

Chile's Natural Laboratories: Eyes of the World to Explore the Microcosm and Macrocosm

Figure 1. This picture was taken at the northern tip of the Salar de Atacama—the largest salt flat in Chile. The flat is close to the town of San Pedro de Atacama, a town in northern Chile very popular among Chilean tourists and international visitors. The salt flat is home to two similar freshwater lagoons that lie very close together: the Ojos del Salar, which translates to "Eyes of the Salt Pan." Photograph by Adhemar Duro, n.d.

Photo by Adhemar Duro. Courtesy of ESO.
Click here to view source.

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Being a unique location worldwide is the first attribute that defines a natural laboratory. In order to establish itself as such, in addition to contributions to knowledge and innovation, two particularities are required: the definition and implementation of a public policy focused on a problem or opportunity of national and/or global relevance and the development of a critical mass in some discipline that has achieved international impact. In the extreme north of Chile, the Atacama Desert has been established as a natural laboratory for astronomical observations, and in the extreme south of the country, the Cape Horn Biosphere Reserve (CHBR) offers an ideal site for research on the impact of climate change (and global socio-environmental change more widely) on biological and cultural diversity. In this section we first introduce the biophysical attributes, and then the conceptual and institutional attributes, of these laboratories—special sites that emerge from Chile as "eyes of the world" to investigate the macrocosm and microcosm.

Read about the foundations and motivations behind our research below, or dive straight into the micro- and the macrocosm by exploring the various thematic chapters in your own order.

The Unique Geographical Locations of Chile's Natural Laboratories

> The original virtual exhibition includes the option to switch between the microcosm and the macrocosm within the individual chapters (see screenshot below).
> Here we present the subchapters one after the other.

Cape Horn Biosphere Reserve

At the extreme south of Chile, Cape Horn's geographical location at the extreme latitude of the American continent is ideal for investigating responses of biodiversity to climate change, since the landform resembles a "summit" with a small terrestrial area particularly sensitive to incremental temperature changes. Southwestern South America and other ecosystems at high latitudes and altitudes are experiencing some of the fastest rates of warming on the planet. However, monitoring and experimental studies of the ecological responses of subpolar and alpine terrestrial biota to climate change have concentrated on subarctic or mountain areas of the Northern Hemisphere. In the Northern Hemisphere, it has been demonstrated that climate change is shifting the distribution and composition of species, key ecological interactions, and ecosystem functioning. At Cape Horn, researchers investigate if similar shifts are taking place in southwestern South America using experimental approaches, modeling and long-term monitoring. At a global scale, this work enables better understanding of the consequences of climate change through analysis of climate systems and the responses of biodiversity and ecosystems to warming trends at high latitudes in general. In this respect, the Cape Horn Biosphere Reserve (CHBR) has at least ten unique attributes:

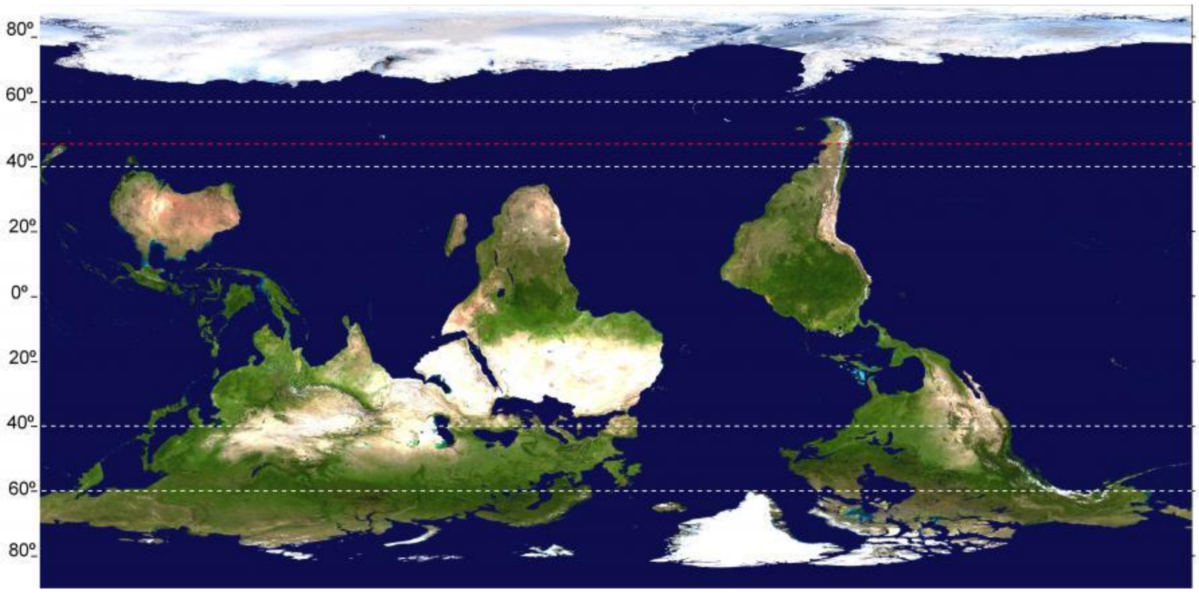

Figure 3. World map with south on top, illustrating how Cape Horn emerges as a summit of the Americas. The red dashed line marks latitude 47° south, which corresponds to the southernmost forests of New Zealand. The forests of Cape Horn are located at 56° south, almost ten degrees latitude further south than those of New Zealand and represent the southernmost forests in the world. White dashed lines demarcate latitudinal ranges between 40° and 60°, showing the stark contrast between the Southern (predominantly oceanic) and Northern (predominantly continental) Hemispheres. Figure modified from Rozzi (2018).

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(1) *The CHBR has no geographic replica in the Southern Hemisphere*. Just as Mount Everest emerges as the highest summit in the world, Cape Horn emerges as the southernmost summit of the American continent (Figure 3). Cape Horn is also home to the highest latitude forests in the Southern Hemisphere. Due to their altitudinal or latitudinal position, both summits, Everest and Cape Horn, are subject to unique and extreme climatic conditions, an attribute that becomes critically relevant when we face global climate change. The document presented to UNESCO to create the CHBR in 2005 begins with this statement.

(2) *Unique biodiversity and high levels of endemism*. The lush forests and moorlands of the CHBR and subantarctic Magellanic ecoregion are home to more than 5 percent of the bryophyte species (mosses and liverworts) described worldwide, which are found in less than 0.01 percent of the planet's land surface. In addition, about 60 percent of the bryophyte species are endemic to the temperate forest biome.

(3) *One of the world's last wilderness areas*. In the twenty-first century, Cape Horn, embedded in the subantarctic Magellanic ecoregion, has been identified as one of the 24 wilderness areas remaining on the planet, because it (i) conserves more than 70 percent of its original vegetation cover, (ii) encompasses an area of more than ten thousand square kilometers that lacks terrestrial connectivity as well as industrial and urban development, and (iii) has one of the lowest human population densities in temperate latitudes (0.14 inhabitants per square kilometer).

(4) *Oceanic climate*. In contrast to the continental climate (freezing winters and hot summers) that characterizes boreal forests, the climate of the subantarctic forests of Cape Horn is moderated by a strong oceanic influence that determines its mild winters and cool summers. The isothermal climatic conditions recorded in the subantarctic forests could be a determinant factor for higher longevity and different migration patterns of birds as compared to the subpolar forests in the Northern Hemisphere.

(5) *Cape Horn: "A geographic funnel" for migratory forest bird species*. In contrast to the Northern Hemisphere boreal forests, which offer a vast expanse of habitat to returning breeding migratory birds, Cape Horn is characterized by a narrow tip where migratory forest birds converge. This geographical attribute has methodological advantages for the study of migration, and provides a unique natural laboratory for interhemispheric comparative studies of the avifaunas of subpolar forests. Due to their migratory behavior, birds of the Northern Hemisphere subpolar forests are studied today as a sensitive biological indicator of global climate change. Birds of subpolar ecosystems in Cape Horn now provide a valuable indicator group to monitor global climate change under environmental conditions that are biologially, geographically, and climatically different from the subpolar ecosystems in the Northern Hemisphere.

(6) *The largest area of temperate and subpolar forests in the Southern Hemisphere*. Cape Horn in the subantarctic Magellanic ecoregion is part of the South American temperate forest biome, which extends over 26 degrees of latitude (30–56° south) and covers an area of about 15.6 million hectares in southwestern South America. This represents the largest expanse of temperate forests remaining

in the Southern Hemisphere, more than twice as much as the 5.9 million hectares of the temperate forests of New Zealand (40–47º south) and Tasmania (41–44º south) combined. Hence, southwestern South America represents a unique natural laboratory.

(7) *The world's cleanest rainwater and streams*. Because southwestern South America is positioned outside of air streams carrying industrial pollutants and receives rainstorms that originated over the southern Pacific Ocean, the austral forests and associated ecosystems are to a large extent free of atmospheric pollution. Precipitation chemistry in this region reveals one of the lowest concentrations of nitrates ever recorded. Therefore, the soils and streams in Cape Horn provide a unique baseline to study the linkages between atmosphere and biosphere under conditions similar to those that prevailed prior to the industrial revolution.

(8) *Insects and ecosystems highly sensitive to climate change*. The high latitude regions of the Antarctic Peninsula and the Magellanic subantarctic have been among the most rapidly warming areas in the world, showing significant glacier retreat and reduction of snow and ice cover in terrestrial and freshwater ecosystems. These regions are inhabited by organisms, such as insects, that are highly sensitive to environmental change and thus are considered models to study the effects of climate change on ecosystems and biota.

(9) *Patagonian ice fields*. Southwestern South America contains vast areas of continental ice: 4,200 square kilometers in the Northern Patagonian Icefield, 13,000 square kilometers in the Southern Patagonian Icefield, and 2,300 square kilometers in the extensive glacier systems of the Cordillera Darwin in Tierra del Fuego and the neighboring archipelagos in the CHBR. Together, these glaciers are (i) the largest ice masses in the Southern Hemisphere, aside from those in Antarctica; (ii) immense reservoirs of fresh water; (iii) unique depositories of records of past climate changes at high southern latitudes; and (iv) more sensitive to global climate change than the Alaskan glaciers.

(10) *The largest area of parks and biosphere reserves in the temperate Southern Hemisphere*. Several large protected areas in the Chilean subantarctic Magellanic ecoregion are providing opportunities for conservation and scientific research within the austral temperate forest biome. The CHBR and the Diego Ramírez Islands–Drake Passage Marine Park protect an area of 25 million hectares.

Today the Cape Horn International Center (CHIC) contributes to three globally relevant innovations to advance understanding of the complex challenges of global socio-environmental change, and to reorient processes that drive biological and cultural diversity losses and ecosystem degradation toward processes of biocultural conservation that promote social, economic, and environmental sustainability. First, CHIC provides a new Scientific and Technological Center of Excellence in a remote area that hosts the world's southernmost forest ecosystems at 56° south (i.e., nine degrees latitude south of the southernmost island of New Zealand). Consequently, Cape Horn has no geographic equivalent in the Southern Hemisphere. Hence, CHIC will contribute to resolving a geographic gap in global monitoring and long-term ecological research about the responses of subantarctic (terrestrial, freshwater, and coastal-marine) biodiversity and ecosystems to climate change. Second, CHIC is implementing a novel biocultural approach that includes multiple forms of ecological knowledge and values, and integrates natural sciences, social sciences, education, and environmental ethics. With this approach, CHIC is investigating biocultural homogenization, a new indirect driver of global socio-environmental change that entails interwoven losses of biological and cultural diversity at local, regional, and global scales. In this way, CHIC will contribute to resolving a conceptual gap by addressing a new indirect driver of global change that combines biotic and cultural factors. Third, CHIC is innovating by integrating this biocultural framework into transdisciplinary research for the design and evaluation of (i) socio-environmental policy, (ii) sustainable economic activities, (iii) educational methodologies linked to biocultural heritage, and (iv) management plans for marine and terrestrial protected areas. This approach is consistent with the UN Sustainable Development Goals and UNESCO's Man and Biosphere Program, which provides an international platform to facilitate its applicability in other regions of the world.

Microcosm Macrocosm

Atacama Desert

The extreme north of Chile is home to the Atacama Desert, the world's driest hot desert that covers an area of 105,000 square kilometers. Due to its geological, geomorphological, and climatic characteristics, this desert has exceptional attributes for astronomic observations. An average of 330 clear nights a year, a dry climate, and the Andean Cordillera with numerous mountains of over 3,000 meters of altitude make the Atacama Desert the best place on the planet to build optical and radio telescopes. One of the major endeavors has been undertaken by the European Southern Observatory (ESO), which with its telescopes has made breakthroughs in astronomy, among them:

Figure 2. The breathtaking Chajnantor Plateau in the Atacama Desert, at an altitude of five thousand meters in the Chilean Andes, houses the Atacama Large Millimetre/submillimeter Array (ALMA). Its harsh environment of dry air, isolation, and nearly non-existent cloud cover makes it one of the best places in the world for astronomical observations. Photograph by G. Rojas, n.d.

Courtesy of the G. Rojas/ESO.
Click here to view source.

(1) *Stars orbiting the Milky Way black hole.* ESO's flagship telescopes revealed empirically for the first time the effects predicted by Einstein's general relativity on the motion of a star passing through the extreme gravitational field near the supermassive black hole in the center of the Milky Way.

(2) *Accelerating universe.* Based on observations of exploding stars, including those from ESO's telescopes at La Silla and Paranal, two independent research teams have shown that the expansion of the universe is accelerating.

(3) *Planet found in habitable zone around nearest star, Proxima Centauri.* ESO's astronomic platform in the Atacama Desert has shown this planet to be a rocky world a little more massive

than the Earth. It is the closest exoplanet to us—and it may also be the closest possible abode for life outside the solar system.

(4) *Astronomers capture first image of a black hole.* ESO, ALMA (the Atacama Large Millimeter/submillimeter Array), and APEX (the Atacama Pathfinder Experiment) contributed to paradigm-shifting observations based on the first direct visual evidence of a supermassive black hole and its shadow. The image reveals a huge black hole at the center of Messier 87, a massive galaxy in the nearby Virgo galaxy cluster.

(5) *Revolutionary ALMA image reveals planetary genesis.* In 2014, ALMA revealed remarkable details of a solar system that is forming, and showed how forming planets are vacuuming up dust and gas in a protoplanetary disc.

(6) *First image of an exoplanet.* ESO's Very Large Telescope Project (VLT) on Paranal obtained the first-ever image of a planet outside our solar system. This planet has a 5-Jupiter mass and orbits a failed star (a brown dwarf) at a distance of 55 times the mean Earth–Sun distance.

(7) *First light from gravitational wave source.* ESO's telescopes in Chile have detected the first visible counterpart to a gravitational wave source. This unique object is likely the result of the merger of two neutron stars, which disperse heavy elements such as gold and platinum throughout the universe.

(8) *Direct measurements of the spectra of exoplanets and their atmospheres.* For the first time, using ESO's Very Large Telescope (VLT), the GJ 1214b planet was studied as it passed in front of its parent star. Some of the starlight passed through the planet's atmosphere, showing that it is either mostly water in the form of steam or is dominated by thick clouds or hazes.

(9) *Cosmic temperature independently measured.* Carbon-monoxide molecules in a galaxy located almost 11 billion light-years away were detected for the first time using ESO's Very Large Telescope. This allowed astronomers to obtain the most precise measurement of the cosmic temperature at such a remote epoch.

(10) *Record-breaking planetary system.* Using ground and space telescopes, including ESO's Very Large Telescope, astronomers found a system of seven Earth-sized planets just 40 light-years away. Three of the planets lie in the habitable zone and could harbor oceans of water on their surfaces, increasing the possibility that the star system could play host to life. This system has both the largest number of Earth-sized planets yet found and the largest number of worlds that could support liquid water on their surfaces.

According to ESO, the coming years will bring new discoveries that will revolutionize our understanding of the universe. The astronomic platform has in part been facilitated by the logistics and technology offered by industries and infrastructures installed in the Atacama Desert, which is rich in metallic mineral resources such as copper (Chile is the world's largest producer and has 28 percent of world reserves) and non-metallic minerals such as lithium (Chile has 39 percent of South American reserves). At the same time, this natural condition of Chile generates growing challenges for sustainable management that respects the unique biological and cultural diversity coexisting in the Atacama Desert.

The original virtual exhibition includes the option to switch between the microcosm and the macrocosm perspectives by clicking on the circles presented above.

A Unique Biocultural Approach

Scientific facts guide the ways we coinhabit the micro- and the macrocosms. Telescopes and hand lenses help us to perceive, understand, and value diversity. The largest beings (such as constellations, stars, and planets) and the smallest (such as mosses, insects, bacteria, and viruses) often remain invisible in our daily lives (Figures 4a and 4b). Science and technology help us to observe and investigate the cosmos, making the invisible visible; but this is not enough. We do not have naked eyes; we see through the "lenses" of our concepts, our values, our worldviews, our cultures. As the way we perceive the world is informed by these various aspects, we introduce the concept of *biocultural laboratories*.

Figure 4a. Slow observations of the “miniature forests of Cape Horn” with the help of a magnifying glass or hand lens help us to perceive, understand, and value the microcosm formed by a rich subantarctic biodiversity of mosses, lichens, and other small organisms. These small but complex ecosystems have essential ethical, ecological, aesthetic, and economic values, which this exhibition aims to introduce. Photograph by Adam Wilson, Omora Park Photographic Archive, n.d.

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Figure 4b. Normally, the Moon is much too large and bright to be a target for the 8.2-meter Unit Telescopes (UTs) that make up ESO's Very Large Telescope (VLT). The sheer power of the VLT is best reserved for much fainter and much more distant astronomical objects, such as exoplanets or exploding stars located at the edge of the visible universe. But back in 2002, it was possible for astronomers and engineers to have an unusual view of our natural satellite. In this case, the Moon's image was projected onto a sandblasted glass plate. Photograph by Gerhard Hüdepohl, n.d.

Courtesy of ESO/G.Hüdepohl (atacamaphoto.com).
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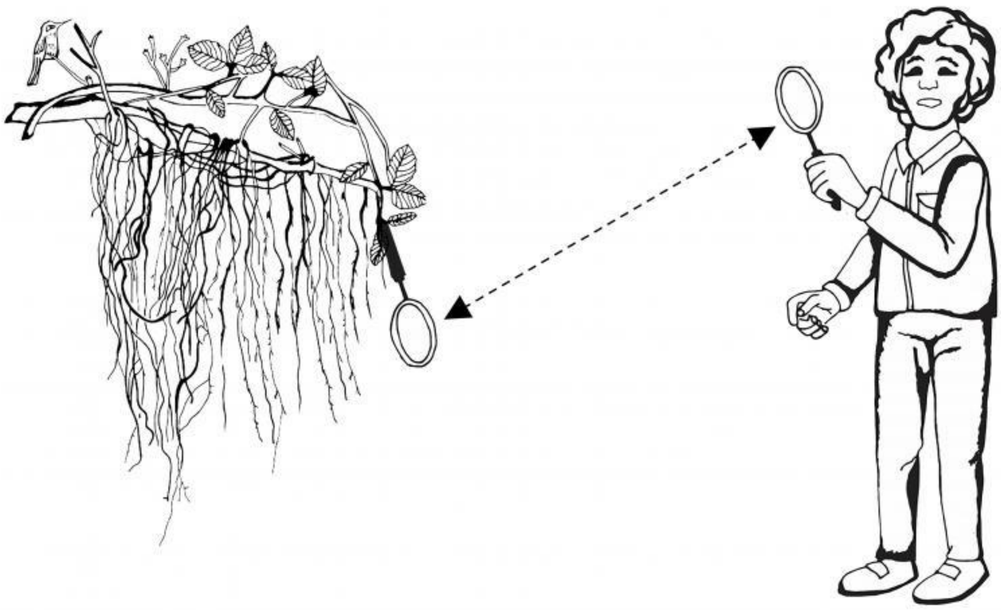
"Biocultural laboratory" is a metamorphosis of the concept of natural laboratory. The concept of natural laboratory focuses on the identification of the world's places that have unique attributes for scientific research. By adapting this concept to that of "biocultural laboratories," we aim to make explicit that biophysical and cultural dimensions are interwoven in the ways of observing and coinhabiting the biosphere, and more broadly the cosmos at multiple scales. This is particularly relevant because our worldviews and languages often remain invisible. In the twentieth century, philosopher Ludwig Wittgenstein called attention to the crucial role that language and concepts play in the ways we see the world. In this virtual exhibition, we highlight the relevance of the diversity of languages and disciplines to observe the world. Sciences, arts, and humanities play complementary roles in the appreciation of the macrocosm and microcosm (Figure 5).



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At its extreme northern and southern regions, Chile aims to forge appropriate technological sensors as much as conceptual lenses to explore the cosmos. In this mission, we consider that philosophy, ethics, arts, and the humanities play a role that is as relevant as the one undertaken by engineering and the sciences. Telescopes and hand lenses contain mathematical and aesthetic languages, concepts, and values that shape our perceptions. To implement this biocultural vision, we take advantage of the major research platforms that Chile has implemented at both its northern and southern extremes. In the latter, among the remote fjords, mountains, glaciers, sea, and intact natural landscapes protected by the CHBR, a group of scientists, artists, philosophers, and other professionals, both Chilean and foreign, initiated a program of biocultural conservation in 1999, which led to the creation of the Omora Ethnobotanical Park in Puerto Williams, the capital city of the Chilean Antarctic Province. The Omora Park research team has discovered that these archipelagoes are home to an exuberant diversity of mosses and lichens, which are very sensitive to climate change (Figures 6a, 6b, 6c).

Figure 6a. Pia Glacier in the Cape Horn Biosphere Reserve, Chile, n.d.

Figure 6b. Ricardo Rozzi and Leopoldo Sancho observing *Rhizocarpon geographicum*, a lichen species that helps to date glacier-retreat processes at Pia Glacier in the Cape Horn Biosphere Reserve, Chile, n.d.

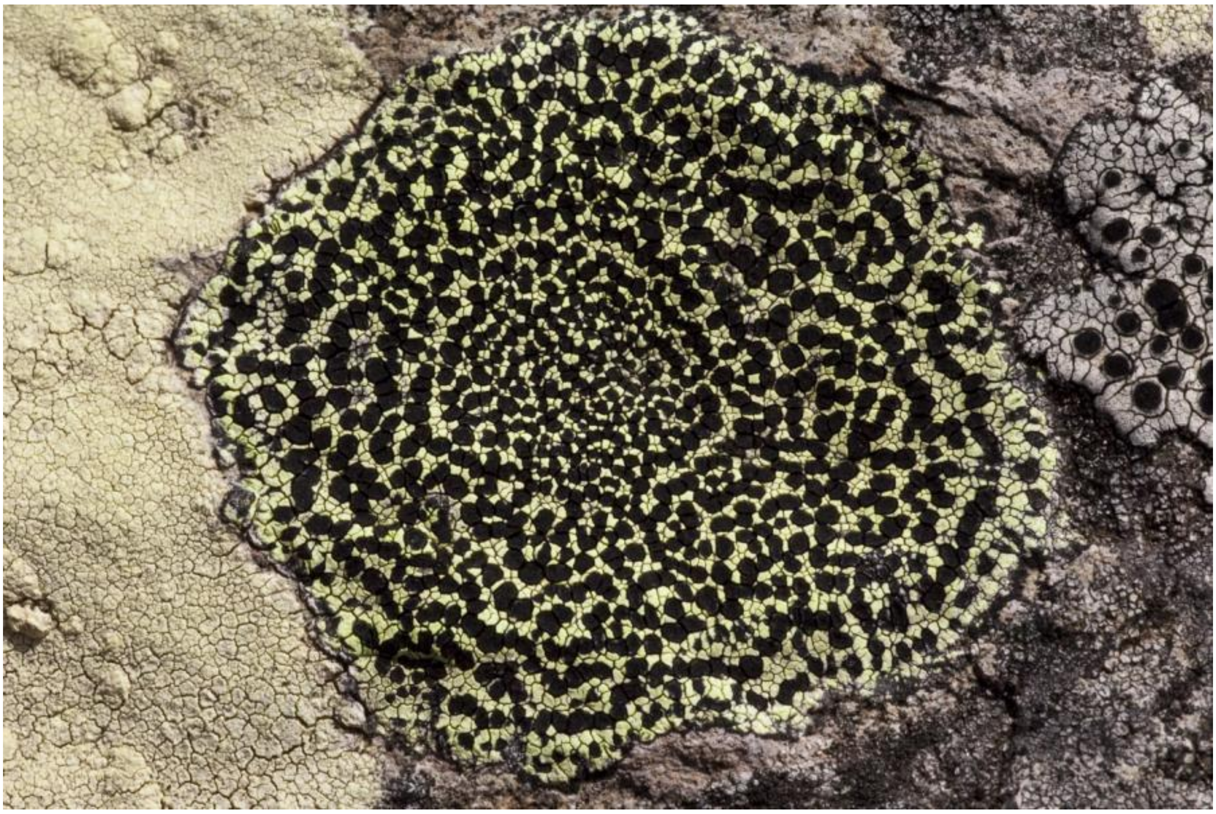

Figure 6c. *Rhizocarpon geographicum*, known as the map lichen, has been used for lichenometry. Its roughly circular diameter has been widely used to determine the relative age of glacial deposits (e.g., moraine systems), providing valuable information about glacial advances and retreats. Hence, this lichen is particularly valuable for assessing climate change. This is a biologically critical tool for climate-change studies. N.d.

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The Omora Ethnobotanical Park was created to provide a biophysical and conceptual space for long-term scientific research, interdisciplinary environmental education, and biocultural conservation initiatives. As a *biophysical space*, it constitutes a biological reserve that protects the Róbalo River watershed, the source of drinking water for the town of Puerto Williams. Across the watershed, one encounters a diverse mosaic of habitats and biotic communities from the shoreline to the highest mountains of Navarino Island (Figure 7). This mosaic is distributed along a sharp altitudinal gradient of one thousand meters in which temperature decreases by 6º Celsius. This makes Omora Park an ideal site to empirically study the impact of climate change on the life cycles and distribution of subantarctic plants, insects, and other organisms (Figure 8). As a *conceptual space*, the biocultural research and educational programs of the park integrate sciences, philosophy, and arts. In this way, the park functions as a natural laboratory as well as a biocultural laboratory, an outdoor classroom and training center, and a biocultural reserve, whose functions are incorporated into three broad domains of action: (1) transdisciplinary scientific research; (2) formal and informal education through school, university, and training courses; and (3) biocultural conservation linked with environmental decision-making and local sustainable development (Figure 9).

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Perceptions and the capacity to observe the micro- and the macrocosm shape our realities, and have profound ethical implications. For example, if we observe only large vascular plants (e.g., trees, shrubs, vines), the implication is clear: we will conserve only vascular plants. We will not be able to see the non-vascular plants (e.g., mosses, liverworts, lichens) that dominate the high latitudes of our planet, and we will thus fail in our conservation efforts at high latitudes. But this violates the basic tenet of conservation biology: to conserve all species diversity. Therefore, we must no longer see conservation of flora as conservation of vascular plants alone. The logic of this argument is inescapable. But logic alone rarely motivates action. Scientific facts will not, on their own, guarantee that the diversity of beings will be conserved. To stimulate the appreciation of the micro- and macrocosms, in this virtual exhibition we propose a "change of lenses" to treasure the beauty of coinhabiting amid an outstanding diversity of gigantic and tiny beings (Figure 10).

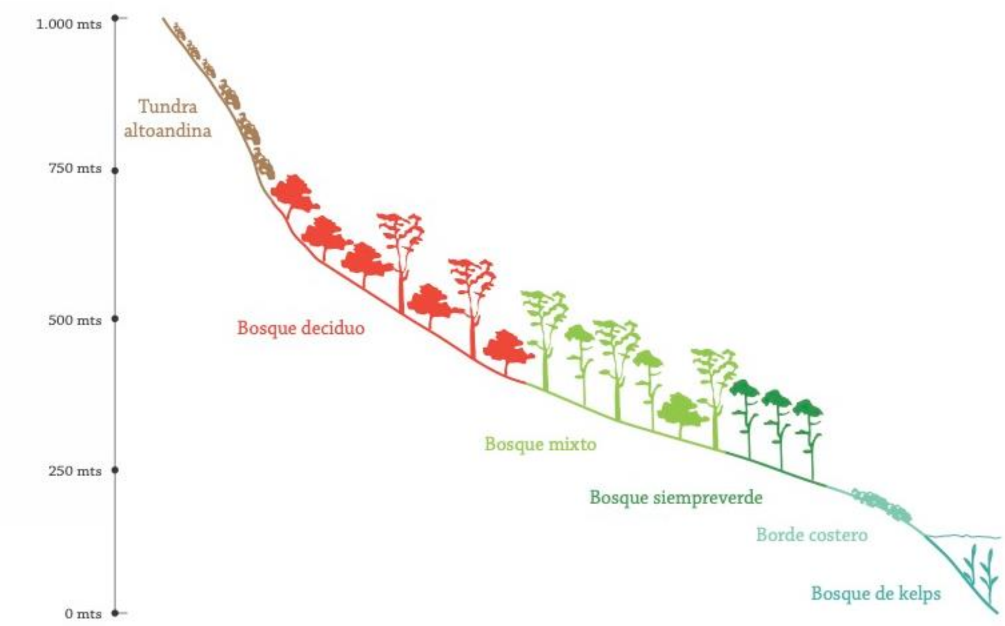

Figure 8. Detail of altitudinal gradient and sampling sites through the Róbalo River watershed protected by the Omora Park. To empirically investigate the impact of climate change on subantarctic insects and plants, long-term study sites along the altitudinal gradient are located at places with different temperatures and climatic conditions. Figure created by Silvia Lazzarino, n.d.

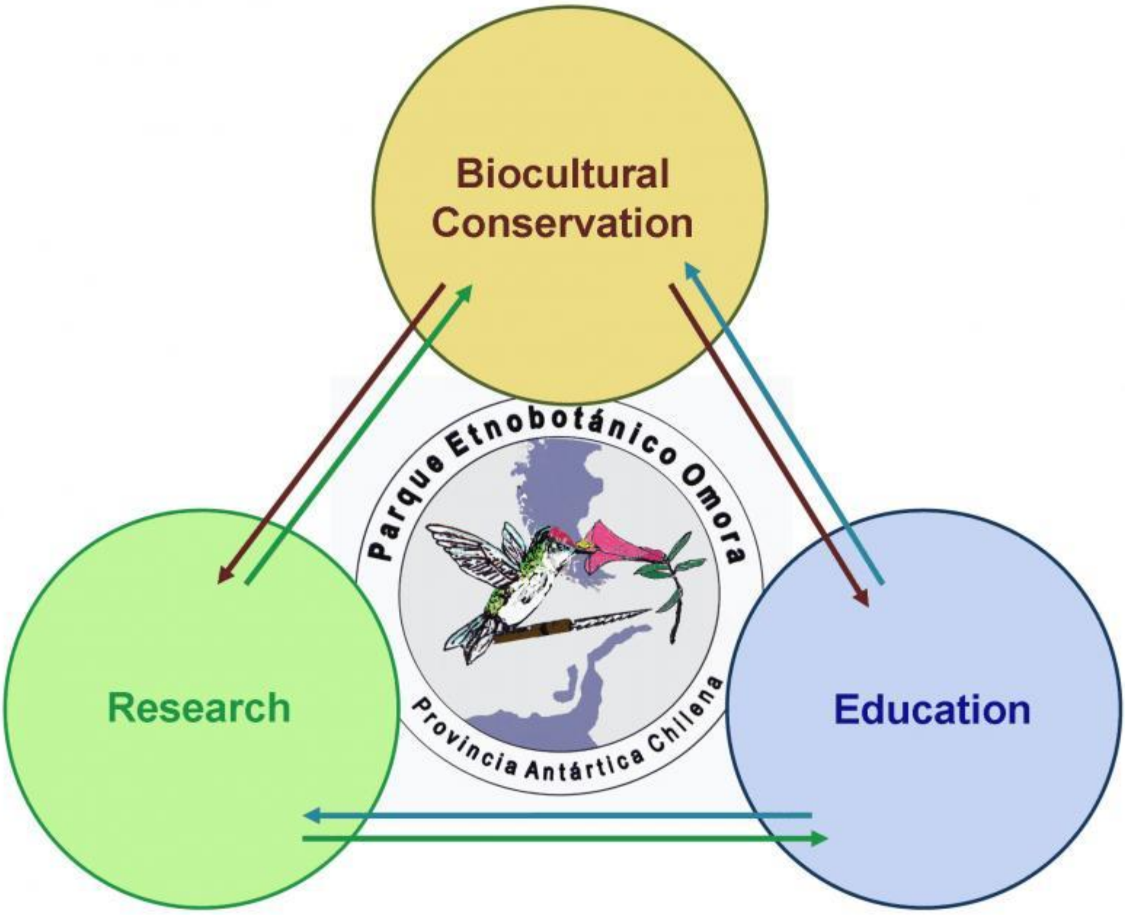

Figure 9. The Omora Ethnobotanical Park's three domains of action are: (i) transdisciplinary research, (ii) formal and informal education, and (iii) biocultural conservation. Omora's logo at the center emphasizes the integration between biological and cultural diversity by depicting the hummingbird *Sephanoides sephaniodes*, or *Omora* in Yahgan language, carrying a harpoon used by the Yahgan Indigenous people to fish in the subantarctic archipelago region, while visiting a flower of the Magellanic copihue (*Philesia magellanica*), the primary source of nectar for the hummingbird in the austral ecoregion. In the Yahgan narratives, Omora is seen as a bird, and at the same time a small person, a spirit who maintains social and ecological order. Figure from Rozzi et al. (2010).

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Figure 10. The Cape Horn International Center (CHIC) is hosted by the University of Magallanes (UMAG), Chile, and inspired by the work *América Invertida* ("Inverted America") by Joaquín Torres García, to forge an institutional image that expresses a biocultural perspective emerging from the geographical south. Adapted image composed in 2016 and first published in Rozzi et al. (2020).

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This virtual exhibition also invites the viewers and readers to observe and appreciate the macrocosm through the windows opened by the telescopes in the Atacama Desert of northern Chile, and the microcosm through the physical and conceptual hand lenses located at the CHBR in southern Chile. We hope to encourage readers to travel virtually (and eventually physically) to these remote, pristine, beautiful regions of our planet, and through their visits come away transformed, seeing and valuing things differently. This transformation aims to orient sensitive and responsible cohabitation. We gain awareness of cohabitation through our abilities to change our lenses, realizing that we are members of communities of coinhabitants, embedded amongst a myriad of beings that have existed before us, and will continue existing after us.

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History of the Exploration

The history of the exploration of the microcosm and macrocosm in Chile is grounded in two factors: (1) the special attributes of unique territories at the southern and northern extremes of Chile (i.e., the subantarctic archipelagoes in the region of Cape Horn, and the Atacama Desert), and (2) the vision and determination of individual researchers and their institutions to discover and implement natural laboratories in these regions.

The original virtual exhibition includes the option to switch between the microcosm and the macrocosm within the individual chapters (see screenshot below).

Here we present the subchapters one after the other.

Serendipity in the Origin of “Ecotourism with a Hand Lens”

In March 2000, Chilean conservation biologist and philosopher Ricardo Rozzi embarked on an expedition to the Cape Horn Islands at the southern end of the Americas, guiding a group of bryologists led by Bernard Goffinet in the search of *Splachnaceae* or “dung mosses” that Goffinet thought might grow on the bones of whales beached on the southern shores of the island. The team experienced several storms while navigating on the *Maroba*, a tiny fishing boat.

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Figure 1. Watershed of the Róbalo River, protected by Omora Park, Puerto Williams, Chile. Photograph by Ricardo Rozzi, n.d.

Researchers were determined to find these dung mosses and began a long hike across a vast peatland, and in their excitement, Ricardo Rozzi became separated from the group and fell into one of the numerous scattered pools. He started to sink. Rozzi felt that this would lead to a natural death. While going down he became fascinated by the astonishing diversity of mosses around the pond. Rozzi thought, “If as a biologist I have not paid proper attention to the magnitude of the diversity of these tiny plants before this moment, I wonder whether decision-makers or teachers in Chile had appreciated this miniature biodiversity.”

Figure 2. Subantarctic Magellanic forests grow from the sea level to the treeline on the mountains in the Cape Horn Biosphere Reserve. Photograph by Paola Vezzani, n.d.

Fortunately, Bernard Goffinet and the team found Ricardo Rozzi in the swamp after a couple of hours, just before he completely disappeared. He survived! However, the image of the exuberant diversity of mosses became fixed in Rozzi's mind, and upon returning to his lab, he systematically began a bibliographic review of bryophytes in Chile. Additionally, with Goffinet, William Buck, and other bryologists associated with Omora Park, a series of floristic inventories was initiated in the Cape Horn archipelagoes (Figures 1 and 2). And it hit them, because they discovered that the subantarctic Magellanic ecoregion constitutes a world hotspot of moss and liverwort (bryophytes or non-vascular plants) diversity.

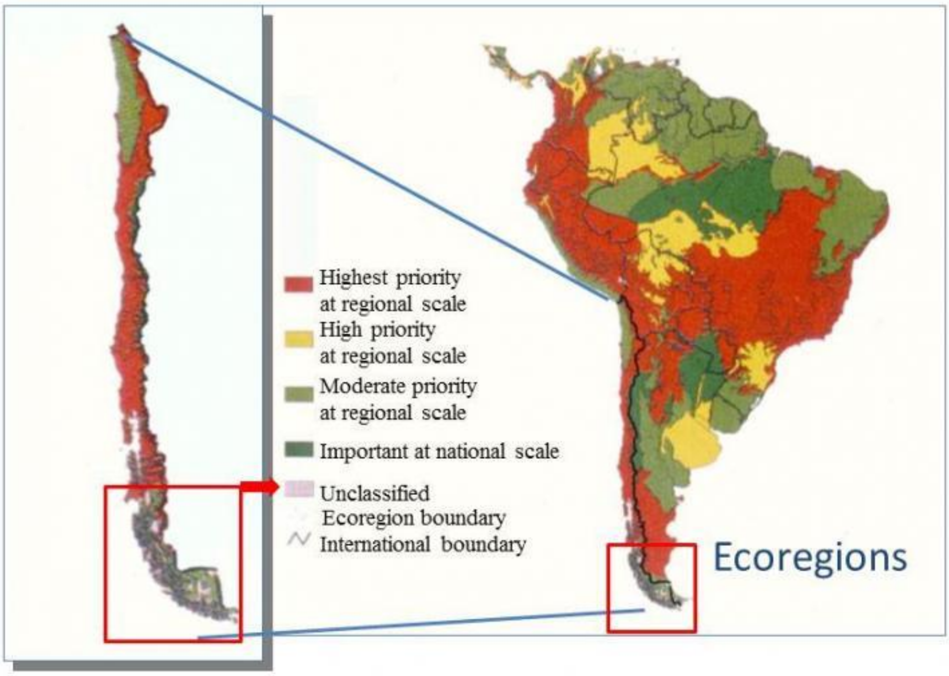

Figure 3a. Map used in discussions with the Chilean Environmental Agency (CONAMA), The Nature Conservancy (TNC), and other organizations to define biodiversity conservation priorities of ecoregions in South America and Chile during the 1990s. The red square highlights the subantarctic Magellanic ecoregion, which was initially categorized as "unclassified." This map was published with modifications in Dinerstein et al. (1995).

Several years earlier, Ricardo Rozzi, who is now the director of the Cape Horn International Center (CHIC), had participated in committees charged with identifying priority sites for conservation in Chile and Latin America. The criteria used at the time and still used today are exclusively based on vertebrate and vascular plant diversity. Looking back now, Rozzi realized that following these criteria, non-vascular plants had been systematically overlooked in this decision-making process. Consequently, at the end of the 1990s, the subantarctic Magellanic ecoregion was classified by the International Union for the Conservation of Nature (IUCN) as unknown and of low priority for biodiversity conservation (Figure 3a).

With the epiphany gained as Rozzi thought he was meeting his swampy death, he and other researchers worked frantically to quantify this overlooked diversity of mosses. They quickly found that over 5 percent of the bryophyte species known to science grow in the archipelagoes of Cape Horn, on less than 0.01 percent of the planet's terrestrial surface. The austral region contains the highest number of species of mosses and liverworts recorded in Chile (Figure 3b). Moreover, in Cape Horn there are more species of non-vascular plants than of vascular plants, sharply contrasting with the ratios of vascular/non-vascular plants found in lower latitude regions (Figure 3b). This discovery stimulated their proposal to "change our lenses" for assessing biodiversity.

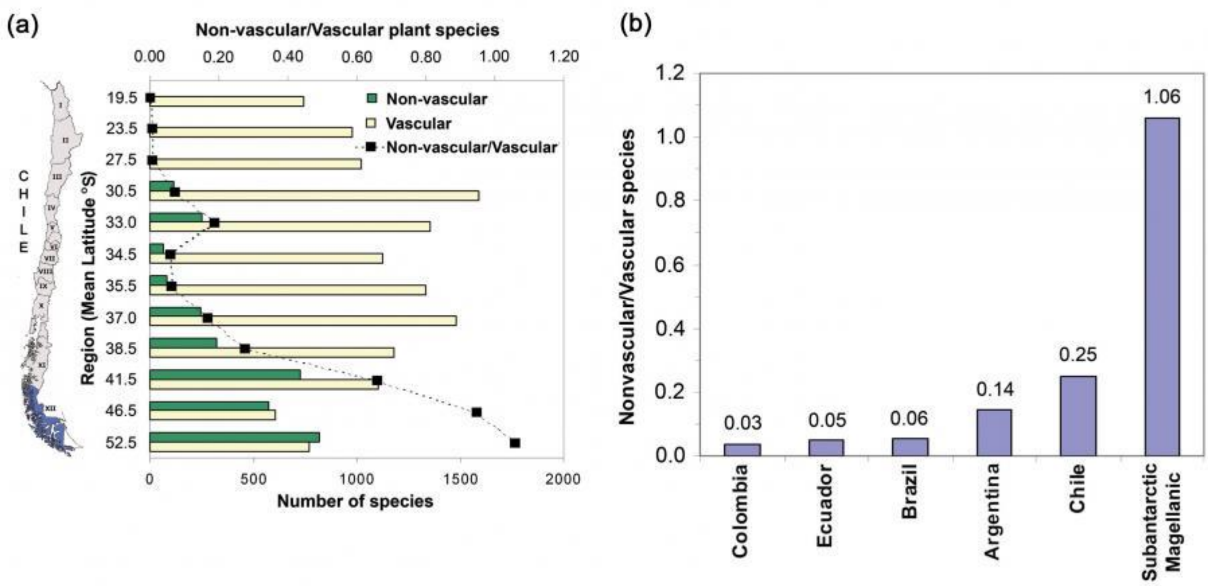

Figure 3b. In Chile, the number of species of bryophytes increases with latitude, and reaches a maximum in the subantarctic Magellanic ecoregion, where it outnumbers vascular plants (a; figure modified from Rozzi et al. (2008). The species richness of non-vascular plants (bryophytes) in the subantarctic Magellanic ecoregion contrasts with lower latitude regions, especially in tropical countries, where its proportion is minimal as compared to vascular plants (b).

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Taxonomic groups and ecoregions shape the "lenses" through which biodiversity is assessed and conserved. Patterns of species richness and endemism used to identify priority areas for biodiversity conservation are strongly biased by our differential knowledge of taxonomic groups. At the end of the twentieth century, assessments of global priorities for conservation relied on the concentration of diversity and endemism of vertebrates and vascular plants. Plant conservation focused almost exclusively on vascular flora, while diversity patterns of non-vascular flora were poorly documented and marginally considered. For this reason, Ricardo Rozzi and other researchers proposed to "change the lenses," and invited conservation biologists to consider not only large organisms but also the smallest organisms, particularly in certain types of habitats. For instance, if the aim is to assess the species richness of intertidal zones in the coasts of the austral archipelagoes, it will be necessary to search for algae, and not only for vascular plants. Analogously, if the aim is to assess high-latitude floristic diversity, it will be inappropriate to base inventories merely on vascular plants, but it will be necessary to also include the non-vascular ones. This second analogy is not as obvious, but it is essential for properly appreciating the floristic diversity of the subantarctic and Antarctic regions.

Figure 3c. Satellite image of the Cape Horn Biosphere delimited by the light blue-dotted line. Located south of Tierra del Fuego, it is the southernmost protected area of the Americas, and the largest one in the temperate and subpolar zones of the Southern Hemisphere. Figure modified from Rozzi et al. (2006 a, b).

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In 2000, the Omora Park research team began floristic inventories and analyses of diversity patterns of this frequently overlooked taxonomic group in a remote and striking geographical area of evergreen broadleaf forests and tundra, which has led us to novel and challenging theoretical and practical questions. The team demonstrated that non-vascular and vascular plants display opposite latitudinal species-richness gradients, and argued that conservation should focus on regional patterns of biome-specific biodiversity-indicator groups, which are often left out of global assessments. In 2005, the research team succeeded in conserving the high diversity of bryophytes of the subantarctic Magellanic ecoregion, which provided the central argument for the creation of the UNESCO Cape Horn Biosphere Reserve (Figure 3c). This is the largest biosphere reserve in southern South America. For the first time in Chile, and the world, a protected area was designated based on the diversity of mosses and liverworts, organisms that up until now have rarely been perceived and valued in the region, country, and conservation community worldwide (Figures 4a and 4b).

Figure 4a. In the Cape Horn Biosphere Reserve, dung mosses belong to a particular family of non-vascular plants that grow on peatland or in forests. Photograph by Adam Wilson, 2010.

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Figure 4b. Dung mosses have colorful sporophytes to attract flies that disperse the spores of the mosses. Photograph by Adam Wilson, 2010.

The success of the first milestone inspired the Omora Park research team to generate two broader applications for the conservation of bryophytes. First, the team invented a novel educational and tourism activity they called "Ecotourism with a Hand Lens" to foster appreciation of the beauty, diversity, and ecological relevance of the "miniature forests" of bryophytes, lichens, and invertebrates. Since 2005, with a magnifying glass in hand, children, teachers, decision-makers, and the general public have gained a new lens to observe, value, and care for the most diverse groups of organisms with whom we coinhabit high-latitude regions (Figures 5a and 5b). Second, beyond the Cape Horn region, the research team has argued that for designing effective conservation strategies, it is essential to broaden the set of groups of organisms that are considered for conservation policies and practices in different regions of the world. To that end, from the extreme southern tip of Chile, Ricardo Rozzi and a team of researchers have proposed a "metaphorical hand-lens" to better investigate, value, and care for the world's biodiversity.

Figure 5a. A family is led by a graduate student guide at the "miniature forests of Cape Horn" interpretive trail, Omora Park. The activity of "Ecotourism with a Hand Lens" helps visitors to appreciate the diversity, beauty, and ecological relevance of lichens and mosses. Photograph by Adam Wilson, January 2010.

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Figure 5b. Close-up of a macro lens used by a visitor during their participation in the activity of "Ecotourism with a Hand Lens." Photograph by Paola Gonzalez, Omora Park, January 2016.

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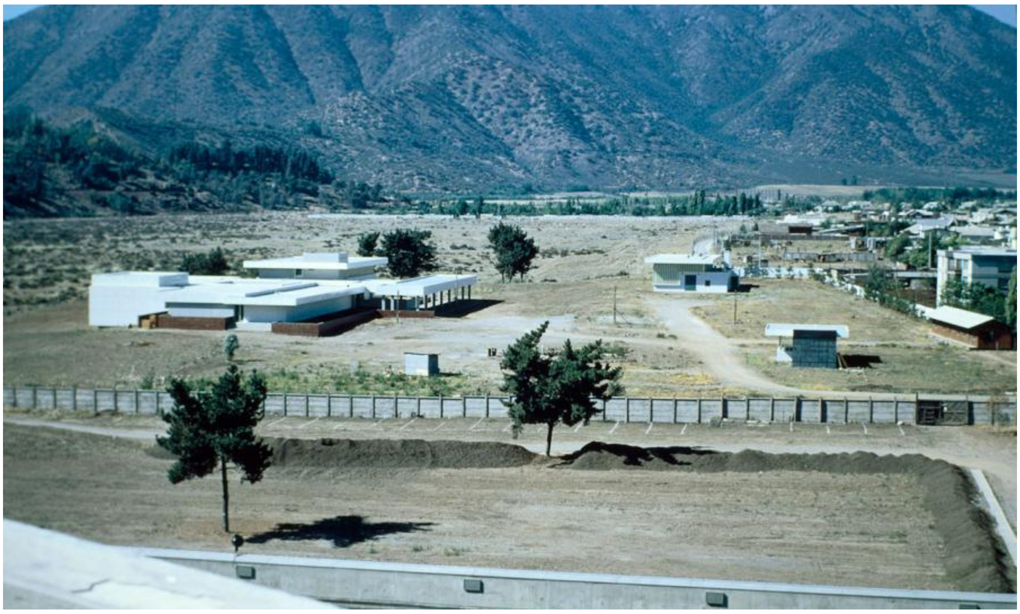
Microcosm Macrocosm

From the Beginnings of Modern Astronomy to the Major Ground-Based Observatories

Modern astronomy in Chile started with the installation of two telescopes on Cerro Santa Lucía in Santiago during the middle of the nineteenth century. This became the basis of the Chilean National Observatory, which was later integrated into the Astronomy Department of the Universidad de Chile. Around the turn of the twentieth century another observatory was established on Cerro San Cristóbal. The first explorations of the Chilean North for astronomical observations were done early in the twentieth century, but major astronomical observatories were established in the 1960s. Several regions between Santiago and the Norte Grande all the way to inland Iquique were investigated for suitable sites, with promising locations found and explored near La Serena, Copiapó, and Calama. The northern sites are characterized by very favorable weather conditions with many clear nights and a stable atmosphere, which results in sharper images.



View of the Vitacura headquarters from the roof of the adjacent United Nations building: the main building of HQ is to the left of the middle of the photograph. Photograph by Eric Maurice, December 1968.

Courtesy of ESO.
Click here to view source.

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In 1963, the European Southern Observatory (ESO) officials were guests of the American Association of Universities for Research in Astronomy (AURA) in the north of Chile. They were looking for a place to build a new observatory. They had done an extensive search for places in South Africa but soon found out that in the north of South America there is a country with wonderful skies for astronomical observation. After the visit and following the inauguration of the Cerro Tololo Inter-American Observatory (CTIO) operated by AURA, ESO decided to place its first observatory on a mountain called Cinchado Norte, north of La Serena, following the excellent sites described by Jürgen Stock. The mountain was locally also known as La Silla and the ESO observatory on this site was inaugurated in 1969, the same year the nearby Las Campanas Observatory of the Carnegie Institution of Washington was established. ESO also established a small office in the Vitacura suburb of Santiago.

La Silla quickly became a large observatory with the installation of many telescopes. The ESO 3.6-meter telescope towered over the site, and in the 1980s two more unique telescopes were added. The Swedish-ESO Submillimeter Telescope (SEST) with a 15-meter dish was the first submillimeter telescope in the Southern Hemisphere and started operations in 1987. SEST was able to see what our eyes and optical telescopes cannot. It was specially designed to observe what we call the cold universe: molecular clouds and dust, objects that are obscure for our eyes but which become bright at submillimeter wavelengths. The ESO's New Technology Telescope (NTT), which represented a step toward active mirror control, was inaugurated in 1989. The NTT already encompassed many features that became characteristic of the eight-meter telescopes of ESO's Very Large Telescope (VLT).

Several years of site selection preceded the construction of the VLT. Finally, Cerro Paranal near the town of Taltal in the coastal range of the Atacama Desert was selected due to an incomparable percentage of clear nights per year (more than 90 percent). The design of the VLT enables the combination of the four unit telescopes in a single telescope as an interferometer. This means that the information from the four eight-meter telescopes can be combined as if they were a single telescope of more than one hundred meters in diameter. Since in astronomy the bigger the telescope the higher the image resolution, the VLT Interferometer (VLTI) produces images with unprecedented detail. The first unit telescope started operations in 1999, and the following years saw the addition of a new telescope until the completion in 2002. In addition, four movable 1.8-meter "auxilliary telescopes" were added to be used in the interferometer. The VLT is among the most productive astronomical telescopes to date. At the same time, the Gemini South eight-meter telescope was built by a multinational collaboration on Cerro Pachon near CTIO in 2000, and two 6.5-meter telescopes on Las Campanas started operating in 2000 and 2002.

The original virtual exhibition features an interactive gallery of images.

View the images on the following pages.

A group of astronomers exploring near the current Cerro Tololo, 1963.

Courtesy of ESO/F. K. Edmondson.
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La Silla mountain ridge as seen from the highest elevation. Image taken in April 1964 by the then-director general Otto Heckmann.

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La Silla mountain ridge as seen from the highest elevation; same view as previous image in 2010.

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The future site of the ELT: Cerro Armazones as seen from Paranal.

Courtesy of G. Hüdepohl (atacamaphoto.com)/ESO.
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While the optical and infrared observatories are placed on sites with stable atmospheres and many clear nights, other ground-based observations profit from the small amounts of water vapor in the atmosphere. A dry place like the Atacama Desert combined with a high-altitude plateau is ideal for observations at submillimeter wavelengths. This is the reason the plain of Chajnantor, at an altitude of over five thousand meters above sea level, was chosen for two Japanese millimeter antennas in 2004. The Atacama Large Millimeter/submillimeter Array (ALMA) now occupies most of the Llano de Chajnantor. The same site hosts the 12-meter antenna of the Atacama Pathfinder Experiment (APEX), which was constructed by the Max Planck Institute for Radio Astronomy in Bonn and the Onsala Space Observatory, and has been operated by ESO since 2005. ALMA, which started operations in 2011, is a collaboration of Europe (ESO member states), North America (United States and Canada), and East Asia (Japan, Taiwan, South Korea) and operates 66 antennas of apertures of 7 meters and 12 meters. The ALMA Offices are installed on the ESO office compound in Vitacura. ALMA is most sensitive to cold objects in space and hence it observes many molecules and cold dust. Like the VLTI, ALMA can also combine its 66 antennas as if they were a single one of 16 kilometers in diameter. The resulting high-resolution images have allowed scientists to identify the places where exoplanets are forming around young stars. Several smaller experiments operated on Chajnantor and its surrounding peaks over the years.

The next generation of telescopes is already being built in the Atacama Desert. The Giant Magellan Telescope (GMT) will observe the southern skies from the Las Campanas mountain with seven eight-meter mirrors mounted together as a single telescope. It is expected to become operational in the late 2020s. ESO's Extremely Large Telescope (ELT), planned to start operating in 2027, is being constructed on Cerro Armazones near the Paranal Observatory. It will have an aperture of 39 meters diameter and will become the largest optical and infrared telescope in the world.

Another new observatory is being planned between Paranal and Armazones: the southern portion of the Cherenkov Telescope Array (CTA). The observatory is composed of 14 12-meter telescopes and 37 4-meter telescopes, which will be installed in the coming years to observe radiation created in Earth's atmosphere by ultrahigh energy particles coming from space. CTA will observe the most energetic and violent events in the universe.

Chile has become the primary location for astronomical observatories due to its clear and stable atmosphere, the availability of high-altitude plateaus, and the dark skies. The Chilean North by now hosts most of the major ground-based optical and submillimetric observatories in the Southern Hemisphere.

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Diversity and Beauty

Diversity and beauty are both in the eye of the observer and in the biophysical world. Often, very small and large objects are overlooked by humans. This section guides readers to appreciate the diversity of small organisms that form the microcosm in the biosphere, and very large and distant objects in the macrocosm of outer space.

The original virtual exhibition includes the option to switch between the microcosm and the macrocosm within the individual chapters (see screenshot below).

Here we present the subchapters one after the other.

Small Is Beautiful

In the northwest arm of the Beagle Channel, we find subantarctic rainforests dominated primarily by the evergreen beech (*Nothofagus betuloides*) and accompanied by the winter's bark (*Drimys winteri*) and low deciduous beech (*Nothofagus antarctica*). The trunks of these trees are covered by thick carpets of liverworts, mosses, and lichens. The floor of these forests is often covered by the devil's strawberry (*Gunnera magellanica*), a small vascular plant that plays a critical ecological role in nitrogen fixation. If we use a hand lens to look closer at these luscious living carpets, we will marvel at the variety of textures, forms, and colors of the foliage of the diverse and beautiful mosses, liverworts, and lichens.

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This picture, taken at the southeast peninsula of Horn Island, shows how at the extreme south of the Cape Horn Biosphere Reserve, subantarctic forests grow only on slopes or cliffs that are protected from the strong winds. Photograph by Ricardo Rozzi, n.d..

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Inside the forests, the floor is covered by liverworts of genera like *Schistochila* (green) and *Gackstroemia* (brunette) that have beautiful foliage and unique reproductive structures such as the gemma cups on a thallus of *Marchantia berteroana*. Photograph by Kristin Hoelting, n.d.

Small Is Essential

Lichens receive the nickname of "ecosystem pioneers" due to their ability to colonize bare rocks and produce fertile soil. This process is critical in the glaciers of the Cape Horn Biosphere Reserve (CHBR). Lichens that contain cyanobacteria have the capacity to fix nitrogen from the atmosphere. In this manner they act as natural fertilizers for the soils. These processes facilitate the ecological succession that begins with the colonization of bare rocks by some mosses and lichens, which penetrate the rocks and form the first soil, thereby promoting the ecological succession followed by the colonization of grasses. In turn, these small plants generate the necessary substrate for the establishment of shrubs and trees. In this way, the little mosses and lichens have been ecologically essential for the establishment of the subantarctic forests in the archipelagoes of Cape Horn after the retreat of glaciers.

Processes of colonization and soil formation are extremely slow, requiring tens or hundreds of years. However, these processes begin immediately when rocks are uncovered, even when they are still semi-submerged in glacier ponds. Photograph by Ricardo Rozzi, n.d.

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When we walk outwards from the glacier front, we can notice rocks that have been free of ice cover for a longer period of time. These rocks are covered by more lichens and mosses and are higher in species richness. Photograph by Ricardo Rozzi, n.d.

Small Is Diverse

In Cape Horn, the forests are very different from the rest of the world. The diversity of trees is very low. We find only six species: three low trees (winter's bark [*Drimys winteri*], pickwood [*Maytenus magellanica*], and the firebush [*Embothrium coccineum*]) and three tall tree species of beeches (the evergreen beech [*Nothofagus betuloides*], high deciduous beech [*N. pumilio*], and low deciduous beech [*N. antarctica*]. However, if we use a hand lens and look at the little flora, we will discover that on a single tree we can find over a hundred species of liverworts, mosses, and lichens growing on its trunk and branches.

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If we examine the trunk and branches of the old tree with a hand lens, we are able to distinguish the luscious and rich diversity of the "miniature forests" formed by foliose liverworts, smooth velvet-like mosses (*Lepyrodon lagurus*), "hairy" mosses (*Dicranoloma sp.*), branchy mosses (*Acrocladium auriculatum*), foliose lichens (*Pseudocyphellaria spp.*, *Peltigera sp.*), fruticose lichens (*Cladonia spp.*), and crustose lichens (*Calicium sp.*, *Chrysothrix sp.*). Photograph by Oliver Vogel, n.d.

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On the interpretive trail of the Omora Ethnobotanical Park, we find this large high deciduous beech (*Nothofagus pumilio*), which is a one-hundred-year-old tree with a large lateral branch. Photograph by Ricardo Rozzi, n.d.

The evergreen Magellanic rainforest in the subantarctic Magellanic ecoregion harbors at least 450 species of mosses and 368 species of liverworts. Hence, at least 818 bryophyte species of the 15,000 species that were known to science until 2008 grow at the southern extreme of South America. This ecoregion represents less than 0.01 percent of the terrestrial surface of the planet but contains more than 5 percent of all the little plants or bryophytes of the world. For this reason, the region of Cape Horn has been identified as a world "biodiversity hotspot."

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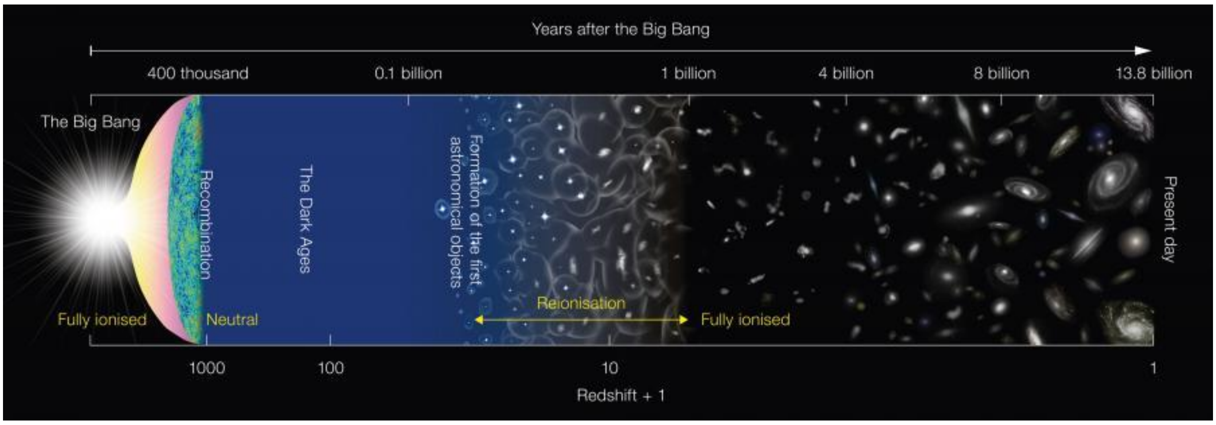
Creating a Diverse Cosmos

Diversity is not only found on Earth; it is key to explaining our cosmos as we know it. Without the diversity of structures, temperatures, and chemistry, we would not have life on Earth. However, diversity has had to be constructed throughout our existence and the cosmos has not always been the same as it is now. In the beginning, right after the Big Bang, the primordial universe was a hot "soup" of particles that slowly began to cool down as it expanded and the first atoms formed. After 370,000 years, the universe was composed mainly of hydrogen and helium, with traces of lithium, and it was finally transparent enough to allow the emission of photons. The first image we have of the universe corresponds to the radiation of these early photons. This electromagnetic radiation is called Cosmic Microwave Background (CMB). The CMB does not look as diverse or beautiful as the images of galaxies or nebula that we are accustomed to seeing, but it is proof of a complex beginning for an incredible future.



This diagram depicts the major milestones in the evolution of the universe since the Big Bang, about 13.8 billion years ago. It is not to scale. The universe was in a neutral state at 400,000 years after the Big Bang and remained that way until light from the first generation of stars started to ionize the hydrogen. After several hundred million years, the gas in the universe was completely ionized.

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Diversity in the Stars

In order to create the first stars and galaxies, the material of our universe had to form structures. Driven mainly by the location of dark matter clumps, this material began to coalesce due to gravity and started to cool down. Cooling is essential, as it allows the material to collapse into a variety of objects, particularly stars. From Earth, stars seem like small flickering dots of light. However, there is a huge variety among them. They are mainly defined by the amount of mass that they accumulate during their formation process. Smaller stars are less massive, cooler, and have redder colors. Sun-like stars are white or yellow, while more massive stars show blue colors and reach very high temperatures. Each of these types of stars has a very different evolution and affects our universe in distinct ways.

This beautiful image, captured with the Focal Reducer and low-dispersion Spectrograph (FORS) on ESO's Very Large Telescope (VLT), shows a field of stars of all ages—some looming close in the foreground and others lurking in the far distance. The distinct red and blue hues are thanks to the use of filters, which allow the selection of specific wavelength ranges of light. The images collected with different filters can be combined in order to create colorful composite images by assigning a particular color to each filter, coloring the images according to the filter used, and then combining the separate images. The result is a spectacular image, which brilliantly represents the various wavelengths of light.
This patch of sky is found in the constellation of Crux (the Southern Cross), an extremely bright section of the Milky Way. It was imaged as part of the ESO Cosmic Gems program, an outreach initiative to produce images of interesting, intriguing, or visually attractive objects using ESO telescopes for the purposes of education and public outreach. The program makes use of telescope time that cannot be used for science observations. All data collected may also be suitable for scientific purposes, and are made available to astronomers through the ESO Science Archive Facility.

Courtesy of ESO.
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Blue giants, the largest of stars, will be able to create high-pressure conditions in their interiors and, through nuclear fusion, form chemical elements up to iron. At the end of their stellar lifetimes, these massive stars collapse in the form of supernovae and the leftover material contracts into either a neutron star or a black hole, the densest objects in the universe. Supernovae are also an opportunity for more chemical elements to form and for the elements created within the star to be spread out into the interstellar medium. Stars like the Earth's Sun combine hydrogen and helium in their interiors to form elements such as oxygen, nitrogen, and carbon, key to life on Earth. These elements are distributed to their surroundings when they expel their outer layers in what is known as a planetary nebula. Finally, the smallest of stars slowly combine hydrogen to form helium and live the longest, which allows us to use them as lower limits for determining the age of our universe.

Beautiful Galactic Structures

Stars can be regarded as the building blocks of galaxies. Each galaxy hosts hundreds of thousands, even millions, of stars. When we observe the most distant objects in the universe, we observe galaxies. Their bright glows allow us to identify them even when they have been dimmed by the distance and expansion of the universe. Galaxies are diverse and beautiful: some show bright spirals where stars are forming and others show an orange-red glow, which can be related to an older stellar population. Galaxies have also allowed us a glimpse into their merging processes, and we have several examples of the cosmic dance that happens as these massive objects interact and join. Perhaps the most beautiful thing that galaxies have shown us is not their shapes or colors, but rather the knowledge that the universe is expanding. Through the study of these galactic structures, we are able to determine the rate at which our cosmos grows and trace the initial moments of the universe as we observe back at the dimmest of objects. The most wondrous aspect of all the amazing astronomical pictures are the questions we can answer by studying them.

Nuzzled in the chest of the constellation Virgo (the Virgin) lies a beautiful cosmic gem—the galaxy Messier 61. This glittering spiral galaxy is aligned face-on toward Earth, thus presenting us with a breathtaking view of its structure. The gas and dust of the intricate spiral arms are studded with billions of stars. This galaxy is a bustling hub of activity with a rapid rate of star formation, and both a massive nuclear star cluster and a supermassive black hole are buried at its heart.
Messier 61 is one of the largest members of the Virgo Cluster, which is made up of more than a thousand galaxies, and is itself at the center of the Virgo Supercluster—to which our Milky Way also belongs. This dazzling beauty was first discovered in 1779, and it has been capturing astronomers' interest ever since. Set against a dark sky littered with galaxies, this image shows the awe-inspiring M61 in its full glory—even at its distance of over 50 million light-years.
This image was taken as part of ESO's Cosmic Gems program, an outreach initiative to produce images of interesting, intriguing, or visually attractive objects using ESO telescopes for the purposes of education and public outreach. The program makes use of telescope time that cannot be used for science observations. In case the data collected could be useful for future scientific purposes, these observations are saved and made available to astronomers through the ESO Science Archive Facility.

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Making Carbon and Climate Change Visible

Climate change is caused by greenhouse gasses that are “invisible” to the naked eye. Being aware of the accumulation of these gasses in the atmosphere can help us to understand what causes climate change. It also helps humans to understand the interconnectedness between humans and the biophysical world. Hydrogen, oxygen, carbon, and nitrogen are the most common chemical elements in the bodies of humans and all other living beings. These elements are also prominent in the atmosphere. Indeed, carbon, oxygen, and hydrogen combine themselves to form the most conspicuous greenhouse gasses: carbon dioxide (CO_2) and methane (CH_4). This section guides readers to learn about how these greenhouse gasses are studied in the microcosm of the peatlands and the macrocosm of the atmosphere.

The original virtual exhibition includes the option to switch between the microcosm and the macrocosm within the individual chapters (see screenshot below).
Here we present the subchapters one after the other.

Peatlands and Global Change

At Omora Park in southern Chile as well as in other forested high-latitude regions, every fall the forest floor is carpeted by thousands of leaves, fallen from trees such as the high-deciduous beech or “lenga” (*Nothofagus pumilio*) and shrubs such as the wild-currant or zarzaparrilla (*Ribes magellanicum*). By the following spring, much of the leaves will have vanished, consumed by fungi and bacteria. These microorganisms feed on dead organic material to retrieve the energy previously locked in the cellulose that makes up the cell wall of plants.

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Cellulose is built from the sugar that plants produce during photosynthesis: solar energy is used to fix carbon dioxide and assemble small sugar molecules into this complex building material. Much of life on Earth relies on the sugar produced during photosynthesis to fuel all cellular processes. Indeed, when sugar is burned during respiration, energy is released, much like when wood is burned and heat is generated. When clearing large forested areas, we not only take out the trees that fix carbon into sugar, but we also release much of the carbon and energy stored in the trees. Deforestation leads to an increase in atmospheric carbon dioxide, a major greenhouse gas, which absorbs solar energy and thereby warms up the atmosphere.

Another major global carbon sink is found belowground. Organic matter that is not decomposed may accumulate sometimes over hundreds and thousands of years. In the *Sphagnum*-dominated peatlands, which cover over 4.4 million hectares in the subantarctic Magellanic ecoregion, the growth of bacteria and fungi is largely inhibited (Figures 1.1 and 1.2). *Sphagnum* is able to acidify the surrounding water to such an extent that many other organisms cannot survive. As the moss grows the older branches and parts of the stems die, and since they are not decomposed, they accumulate. Year after year, a new layer is added. Over periods of hundreds or even a few thousand years, this layer of dead organic material (i.e., peat) may reach two or three meters in thickness. As one of the most carbon-rich ecosystems, peatlands are a reservoir of energy and not surprisingly have been harvested to heat homes in large parts of the world.

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Figure 1.1. Mosses of the genus *Sphagnum* dominate the subantarctic peatlands forming dense and deep cushions, like those found in the lowlands of Omora Park. *Sphagnum magellanicum* (reddish) and *S. fimbriatum* (green) are the most abundant species of peat mosses in the Cape Horn Biosphere Reserve. Photograph by Paola Vezzani, n.d.

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Figure 1.2. Peatlands include not only mosses of the genus *Sphagnum* but also a diversity of other mosses, liverworts, and small vascular plants. This picture illustrates the liverwort *Gackstroemia magellanica* (the dark brown reddish leafy liverwort), the moss *Sphagnum magellanicum* (the bright yellow), and the small vascular plant *Rubus geoides* (the green leaves on the right). Photograph by Adam Wilson, n.d.

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Figure 1.3. In the Cape Horn Biosphere Reserve, the subantarctic forests are embedded in a matrix of tundra. It includes vast peatlands dominated by *Sphagnum magellanicum*. The same species can also be encountered in the lowlands of Omora Park. The Magellanic moorland complex represents the largest wetland area at high latitude in the Southern Hemisphere. Photograph by Adam Wilson, n.d.

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Peatlands occur at high latitudes and altitudes, and in some areas the peat layer is several meters thick, as is the case in the lower parts of Omora Park and other sites of the Cape Horn Biosphere Reserve (CHBR) (Figure 1.3). In fact, peatlands hold more carbon, and thus energy, belowground (in peat) than do tropical rainforests aboveground (in wood).

Peat accumulates because organic material is not decomposed fast enough. The microorganisms that recycle the organic matter are inhibited by the acid water but also by the lack of oxygen. Besides acidifying the water, *Sphagnum* is also able to raise the water table, thereby creating an oxygen-free environment. All organisms need oxygen to burn sugar and retrieve the energy bound in cellulose, just as a candle requires oxygen to burn. If the water table drops, due to a rise in evaporation triggered by higher global temperatures or to less rainfall, microorganisms will be able to break down the peat, releasing carbon dioxide and energy into the atmosphere, amplifying the change in global climate. The amount of carbon in peatlands throughout the world is so large, and the consequences of its release so significant, that peatlands are seen as a ticking time bomb. The subantarctic peatlands form part of the Magellanic moorland complex, which is the largest wetland area at high latitude in the Southern Hemisphere, and we can keep the bomb from exploding by preserving the peatlands of Omora Park, the CHBR, and other regions of the planet.

Microcosm Macrocosm

Measuring the Abundance of Greenhouse Gasses with ESO Telescopes

Earth's atmosphere affects observations carried out by ground-based telescopes in multiple ways. One of them is the imprint of distinctive features (absorption lines) in the spectra of astronomical objects caused by the very molecules it is made of, including oxygen, nitrogen, water vapor, carbon dioxide, and methane. The shape of these features depends on temperature and pressure in the various layers of the atmosphere. To study astronomical objects, astronomers need to make sure the spectra of these objects are cleared of the features imprinted on them by Earth's atmosphere.

To do this, astronomers used to spend precious telescope time to systematically observe "telluric standard" stars close in time and with similar coordinates as their science target. These stars are known to have no intrinsic features; hence, the ones found are identified as being caused by Earth's atmosphere.

For the past few years, astronomers at European Southern Observatory (ESO) observatories have been able to use a different method to correct their observations thanks to an ESO software tool that creates synthetic transmission spectra of the atmosphere using the spectra of the astronomical target themselves. In addition, this method allows them to save telescope time. However, this scheme requires many calculations to determine the abundance of each molecule and may not be applicable in some cases.

In a proposed development, the number of calculations can be much reduced if, first, telluric-standard stars are regularly observed during twilight. These observations would be automatically processed by the tool only to determine the abundances of molecules other than water vapor (whose abundance can vary greatly on short timescale and therefore requires specific equipment) and would then be input into a dedicated database. Finally, the astronomer would use the tool but automatically fetch the abundances of the different gases from the database for the time of their observations instead of calculating them: in other words, the tool would automatically calculate the transmission of the atmosphere for the conditions matching the ones that took place during the observation of the science target with an accuracy of within two percent.

Hence ESO will have a database of abundances for a number of greenhouse gases determined in the heart of the Atacama Desert, which allows experts to study climate change from a unique location. The database is planned to be included in one of the Network for the Detection of Atmospheric Composition Change stations, so that it can be made available to anyone wishing to use it.

As an example, the following figure shows the evolution of the abundance of CO_2 from early 2014 to March 2020, based on data obtained with the X-shooter, a multiwavelength (300–2,500 nanometer) spectrograph mounted inside one of the VLT telescopes at the ESO's Paranal Observatory. It clearly shows that the amount of this greenhouse gas in the atmosphere above Paranal has increased by more than three percent over this period. As Paranal is located in a desert in the Southern Hemisphere, measurements show fewer seasonal variations compared to those obtained from other locations. Once in operation, the proposed scheme would regularly provide measurements of the abundance of several greenhouse gases based on data obtained with more than five instruments.

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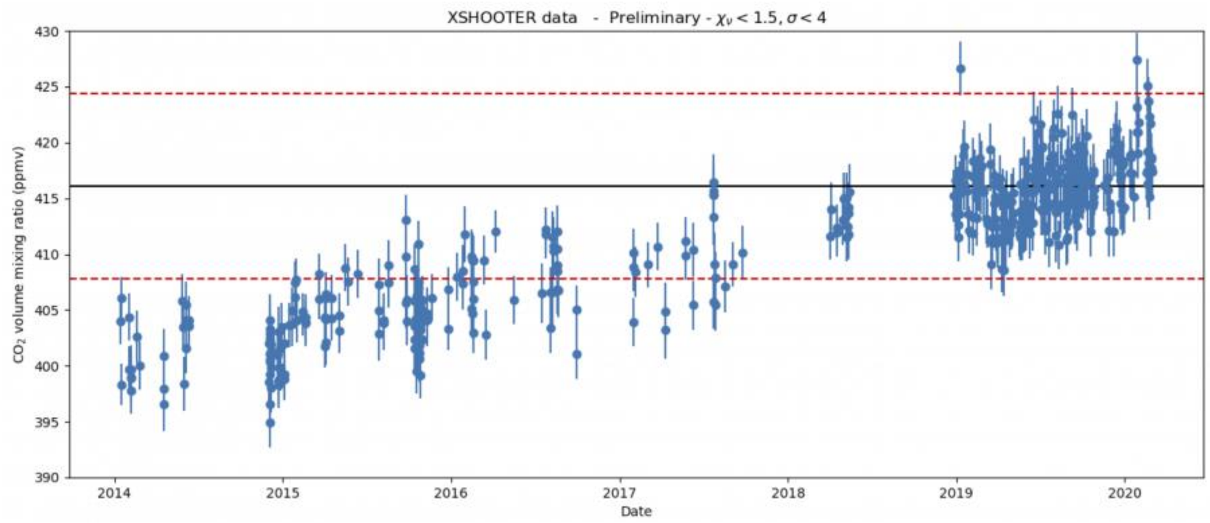

Results of a preliminary feasibility study showing the evolution of CO2 above ESO's Paranal Observatory based on spectra obtained with the X-shooter instrument on ESO's Very Large Telescope. The solid black line shows the mean value of the measurements obtained in 2019 while the dashed red lines correspond to +/– two percent relative to it.

Courtesy of ESO/Smette.

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Making the Origin of Water and the Cleanest Waters on the Planet Visible

Water is a simple molecule composed of two hydrogen atoms and one oxygen atom. It is a very common compound in the universe, and it is essential for all forms of life on Earth. For this reason, biologists and astronomers converge in their research programs to study and value this precious element. This research is not only fascinating but also pressing in the context of climate change. As stated by the Intergovernmental Panel on Climate Change (IPCC), the water crisis has become a central environmental, social, cultural, economic, and ethical crisis in the twenty-first century. This section guides readers to learn about the unique attributes of freshwater ecosystems and the microcosms inhabiting them in the Cape Horn Biosphere Reserve (CHBR) and about the wonders of the origins of water disclosed by recent explorations of the macrocosm conducted by astronomers based at the Atacama Desert in Chile.

> The original virtual exhibition includes the option to switch between the microcosm and the macrocosm within the individual chapters (see screenshot below).
> Here we present the subchapters one after the other.

Underwater Inhabitants in the Rivers of Cape Horn

Water is an essential component for the survival of all beings that live on our planet. The subantarctic Magellanic ecoregion contains the cleanest rainwater in the world, as it is located outside of the air currents that transport pollutants from the Northern Hemisphere. The rivers, lakes, and lagoons of this ecoregion are home to a wide variety of aquatic invertebrates or *underwater inhabitants* that help maintain the purity of its waters. These organisms inhabit all rivers, streams, and lakes around the world, and include organisms such as arthropods (insects, arachnids, shrimps), mollusks (snails), and worms (freshwater worm and leeches), among others. The great majority live in benthic habitats, such as rocks, sand, or woody debris. Insects, the most

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diverse and abundant animals on the planet, are one of the most important and least-known members of this group of organisms. Their adaptability and diversity of life forms have allowed them to colonize almost every ecosystem on the planet, from the driest deserts to the Antarctic continent.

Meridialaris chiloensis (Ephemeroptera), an aquatic insect and underwater inhabitant found in the Róbalo River watershed. Photograph by Gonzalo Arriagada Kritzler, n.d.

Edwardsina sp. (Diptera), another of the unique inhabitants found along the Róbalo River watershed. Photograph by Gonzalo Arriagada Kritzler, n.d.

Field Environmental Philosophy (FEP)

We are immersed in a crisis of civilization that entails the rupture of interhuman and interspecies relations. To address this and other social and environmental changes, it is necessary to reconnect global society with biological diversity and cultural diversity, and their interrelationships (in short, biocultural diversity). A first challenge is that biocultural diversity is today, in general, invisible in the fields of education and the concepts of well-being that prevail in our society. For example, despite their impressive diversity and ecosystem relevance, insects are undervalued and rarely considered in conservation efforts, except for those that are medically or economically important. We therefore require methodologies that contribute to making biocultural diversity visible and thus reconnecting it with the globalized world. To achieve this reconnection, Ricardo Rozzi and the Omora Park research team created a novel methodological approach called "Field Environmental

Philosophy" (FEP). Participants use methods from sciences, humanities, and arts to not only learn about biocultural diversity, but also propose and practice respectful and responsible ways of coinhabitation.

Scholars and students conduct ecological research focused on the biodiversity of freshwater and terrestrial insects and their adaptations to global environmental change along the Róbalo River watershed. Photograph by Gonzalo Arriagada Kritzler, n.d.

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"Underwater with a Hand Lens" at Omora Park. Photograph by Gonzalo Arriagada Kritzler, n.d.

In this context, during the last 20 years at Omora Park, researchers have integrated ecological sciences, education, and environmental ethics through the praxis of FEP to contribute to the valuing and conservation of freshwater insects, their habitats, and life habits in the Cape Horn Biosphere Reserve (CHBR). Our ecological work has focused on the adaptations and biodiversity of freshwater and terrestrial insects to global environmental change along the Róbalo River watershed, which provides drinking water to the city of Puerto Williams on Navarino Island. We have discovered, for example, that these organisms can be considered sentinels of climate change, providing early signals of its impacts within these austral ecosystems. At the same time, our philosophical work has focused on contributing to overcoming the conceptual omission of the intrinsic value of freshwater invertebrates, their habits, and habitats, and to recognize and ethically value these organisms. In this context, we designed and implemented an interpretative trail within Omora Park, where we practice the activity "Underwater with a Hand Lens." Visitors are guided through five interpretive stations, where they can experience direct face-to-face encounters with *underwater inhabitants*, their habitats, and habits. The praxis of FEP, as it applies to freshwater insects in the CHBR, has allowed us to reach a wide cross section of people and increase awareness and value for these often overlooked organisms. These experiences of direct "face-to-face" encounters have been essential for promoting the valuing, respect, and ethical treatment of these small, beautiful, and crucial coinhabitants. Through the generation of these concrete actions, we aim toward contributing to the transformation of the prevalent ways in which global society understands, values, and relates to freshwater ecosystems and their coinhabitants, fostering more respectful and sustainable life habits in the short and long term.

Microcosm Macrocosm

Making the Origin of Water Visible

Water is a simple molecule composed of two hydrogen atoms and one oxygen atom. It is a very common compound in the universe and it is essential for all forms of life on Earth, as it plays a key role in many biochemical processes like photosynthesis or cellular respiration. For this reason, astronomers are focusing on the search for water in Earth's solar system, other planetary systems, and in the large, distant universe.

The presence of liquid water on planet surfaces is considered key for the development of life as we know it. This has motivated the astronomical community to invest their efforts in the characterization of extrasolar planets in the habitable zone, which is the warm region close to the star where water could be in liquid state.

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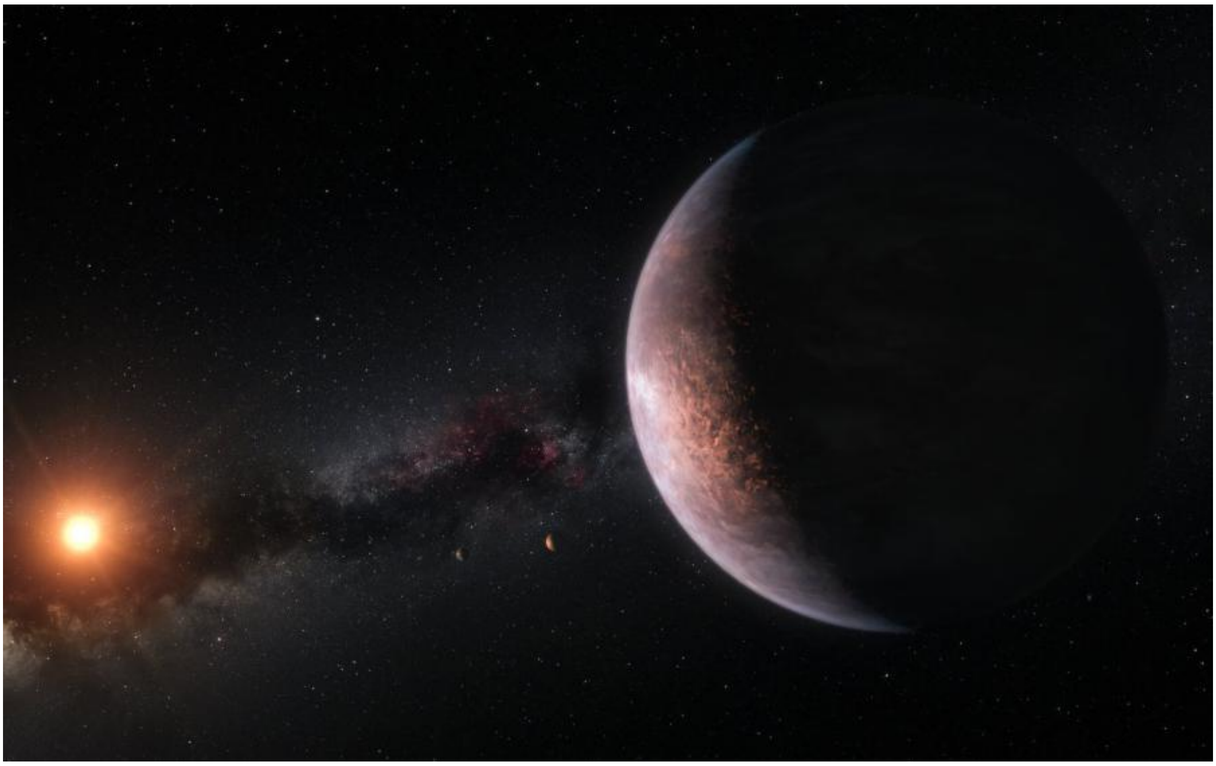

Artist's impression of the TRAPPIST-1 planetary system. Astronomers believe some of the planets in this system are rich in water.

Courtesy of ESO/M. Kornmesser.

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Water is found in gaseous and ice forms in many solar system bodies like planets, moons, comets, and asteroids. In particular, evidence for the possible presence of liquid water under the frozen surfaces of several moons orbiting the giant planets of Earth's solar system is inspiring future solar system space missions. Europa and Encedalus, moons orbiting Jupiter and Saturn respectively, have shown evidence of subsurface liquid water oceans. Even if they are far away from the Sun and from the habitable zone, these moons undergo internal heating due to the stretching and flexing they experience in their eccentric orbits around their giant planet, which results in the existence of liquid water below their surface.

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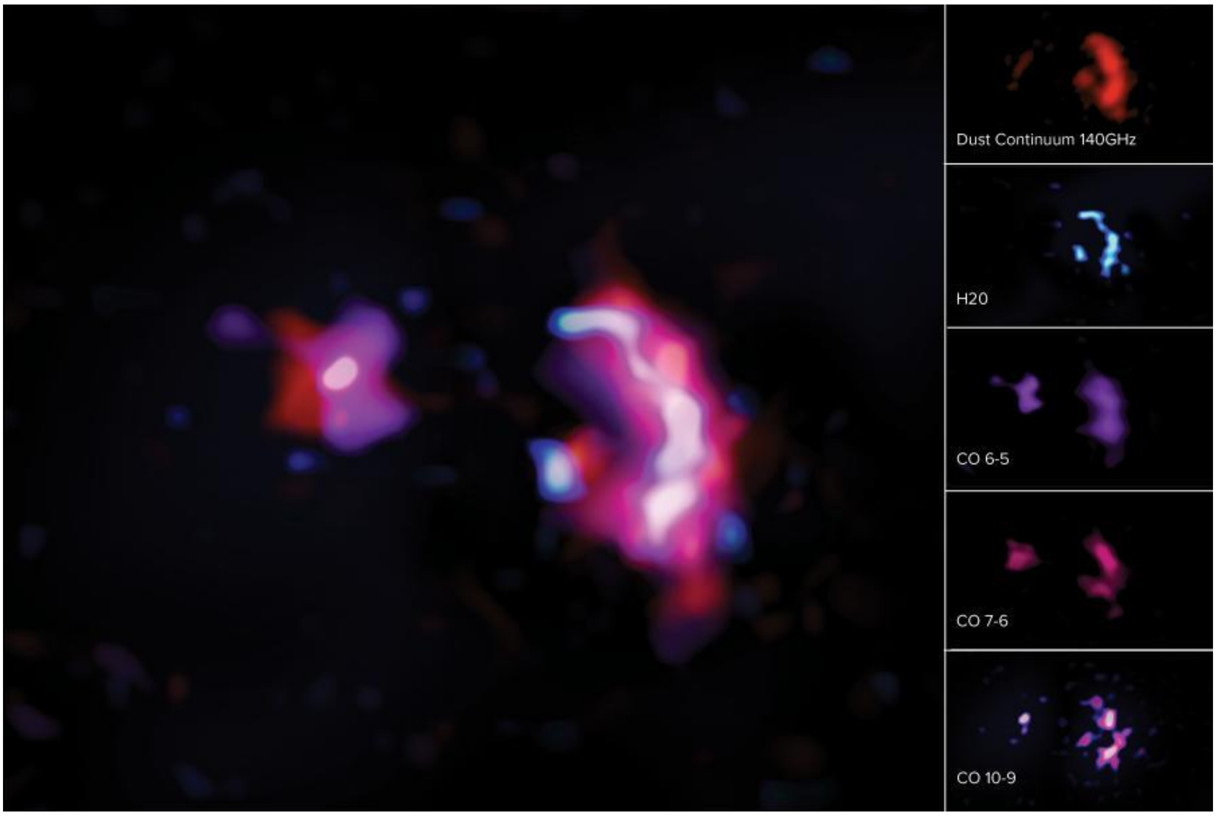
The origin of water on Earth is one of the open questions in astronomy. Icy comets and asteroids could be one of the main water suppliers, while part of the water on Earth may have formed *in situ* during the process of Earth's formation. Recent studies on the isotope composition of water revealed that the ratio of deuterium to hydrogen in comets is higher than on Earth, suggesting asteroids could be the main suppliers of water on our planet.



These science images show the molecular lines and dust continuum seen in ALMA observations of the pair of early massive galaxies known as SPT0311-58.

Courtesy of ALMA (ESO/NAOJ/NRAO)/S. Dagnello (NRAO).

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Water is not only found in moons and planets, it is also present in the regions where new stars and planets form, around old, evolved dying stars, and in other galaxies, some of them in the distant, early universe. The oldest and most distant evidence of water in the universe was found in the star-forming galaxy SPT0311-58, 12.88 billion light-years from Earth. The discovery was made from Chile, using the Atacama Large Millimeter/submillimeter Array (ALMA), operated by the European Southern Observatory (ESO) together with international partners. ALMA is equipped with a set of receivers that can detect water-molecular transitions emitting at different wavelengths of the millimeter and submillimeter region of the electromagnetic spectrum, and from the faintest and coldest objects in the universe.

The most powerful ground-based telescopes on Earth hosted by Chile, like ALMA, ESO's Very Large Telescope, and, in the future, ESO's Extremely Large Telescope, will play a key role in the study of water in the universe and in the characterization of the atmosphere of planets around stars other than Earth's sun.

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Natural Laboratories

Being a unique location worldwide is the first attribute that defines a natural laboratory. However, to become such, it also requires the vision of researchers and public policies that allow it to be implemented. This confluence of biophysical, cultural, and political attributes has come together to create the natural laboratories of Cape Horn in the subantarctic Magellanic ecoregion and in the Atacama Desert in Chile. In its biophysical dimension, the Cape Horn Biosphere Reserve (CHBR) has no biogeographic replica at a planetary level, and provides a baseline from which it is possible to investigate some ecosystems under preindustrial conditions to allow a better understanding of climate change. In its cultural dimension, researchers have generated a methodological approach called "field environmental philosophy" for integrating the natural sciences along with the humanities, the arts, and ethics into biocultural conservation, education, and research. In Atacama, the place with the clearest skies on the planet, the world's largest platform for the development of astronomical observations has been established. This section guides readers to learn about the research platforms at these two unique natural laboratories.

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The Cape Horn Research, Education, and Conservation Platform

In 2000, the Omora Ethnobotanical Park, Navarino Island, was created as a natural laboratory, an outdoor classroom, and a long-term ecological research (LTER) site for the Cape Horn Biosphere Reserve (CHBR). It also serves as a "sentinel for climate change" because Omora Park protects a river basin that includes habitat types characteristic of the CHBR in an altitudinal gradient with a

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thermal decrease analogous to that which occurs with increases in latitude (Figure 1). This makes it an ideal site for studies on climate change and its impact on biota and subantarctic ecosystems.

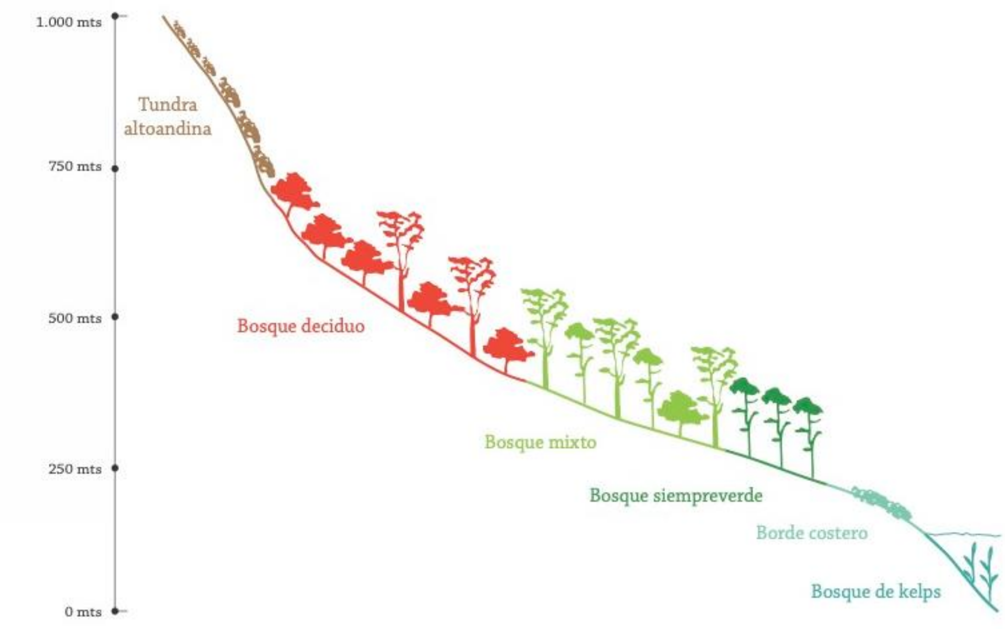

Figure 1. Detail of altitudinal gradient and sampling sites through the Róbalo River watershed protected by the Omora Park. To empirically investigate the impact of climate change on subantarctic insects and plants, places with different temperatures and climatic conditions are selected as long-term study sites along the altitudinal gradient. Figure created by Silvia Lazzarino, n.d.

Among the functions of biosphere reserves is the support scientific research, education, training, and monitoring. In the CHBR, created in 2005, this function has been fulfilled with the creation of the Omora Ethnobotanical Park in 2000, and its implementation in 2008 as a cofounder site of the Chilean Long-Term Socio-Ecological Research Network (LTSER). In 2016, this network was strengthened with the addition of the new Cape Horn Long-Term Socio-Ecological Research Network (LTER-Cape Horn). The latter includes the Omora Ethnobotanical Park, and three new sites added to the monitoring of the subantarctic Magellanic ecoregion (Figure 2).

In 2015, UNESCO approved the Report of the First Periodic Review of the CHBR that proposed the protection of the Diego Ramírez archipelago and the creation of the Diego Ramírez Islands–Drake Passage Marine Park (DRMP). The promulgation of this new park was finally achieved on 2 February 2018, and it was officially decreed by the Chilean government on 21 January 2019 (Official Gazette 2019). In this context, the new LTER-Cape Horn network has been given relevance on a local and global scale. At the local scale, it covers a representative environmental heterogeneity of the great diversity of landscapes and terrestrial, freshwater, and marine ecosystems that characterize the subantarctic Magellanic ecoregion. On a global scale, the terrestrial ecosystems of the LTER-Cape Horn network stand out for two main reasons: (1) these subantarctic ecosystems lack a geographical replicate in other continents of the Southern Hemisphere, and (2) high-latitude ecosystems are especially sensitive to global climate change. Thus, the LTER-Cape Horn network helps to overcome critical geographical gaps in the implementation of the International Network for Long-Term Ecological Research Network (ILTER). The implementation of the LTER-Cape Horn network is based on a close collaboration with various public institutions: the Ministry of National Assets, the Ministry of the Environment, the Undersecretariat of Fisheries and Aquaculture of the Ministry of Economy, Development and Tourism, the National Forestry Service, the General Water Directorate of the Ministry of Public Works, the Chilean Navy, the Chilean national law enforcement police (*Carabineros de Chile*), the municipality of Cape Horn, the provincial government of Chilean Antarctica, and the regional government of Magallanes and Chilean Antarctica. In the future, the LTER-Cape Horn network and the Cape Horn Center aim to strengthen the participation of the local community, especially the Yaghan Indigenous Community of Bahía Mejillones, artisanal fisheries, tour operators, and the educational community, including private actors. Located at the "southern summit" of the Americas, Puerto Williams, capital of the Chilean Antarctic Province, emerges as a global hub for transdisciplinary subantarctic research.

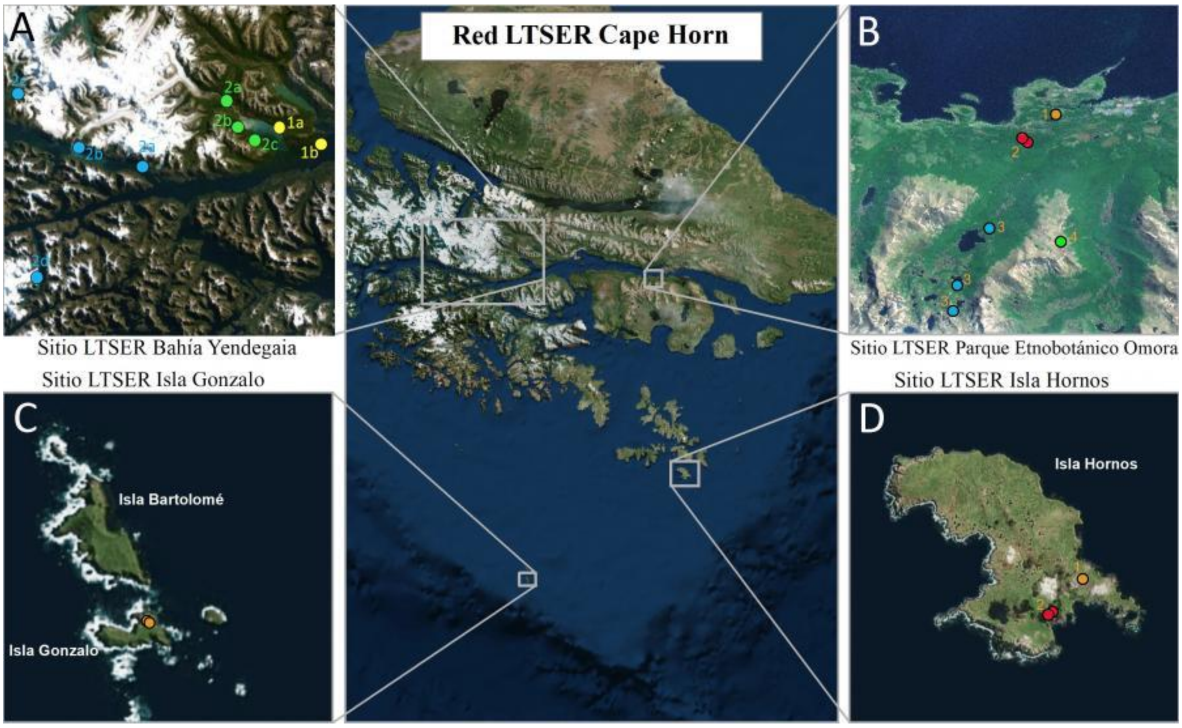

Figure 2. The LTER-Cape Horn Network with its four main sites for long-term ecological studies, from south to north: (1) Gonzalo Island (56°31' south, 68°43' west), at the southern end of the Diego Ramírez Archipelago, with subantarctic vegetation dominated by grasses and cryptogams, devoid of woody species; (2) Horn Island (55°58' south, 67°13' west), at the southern end of the Cape Horn Archipelago, hosting the southernmost forest ecosystems on the planet, which are dominated by the evergreen beech (*Nothofagus betuloides*); (3) Omora Park (54°57' south, 67°40' west), Navarino Island, an ideal site for studies on climate change and its impact on biota and subantarctic ecosystems, since it protects a watershed that includes a representative mosaic of characteristic habitats of the CHBR in an altitudinal gradient with a thermal decrease analogous to that which occurs with increases in latitude; and (4) Caleta 2 de Mayo Site (54°52' south, 68°41' west), Yendegaia Bay, in an ecotonal zone between evergreen and deciduous forests (product of the local climate gradient), at a site that will be central to future connectivity between continental Chile, Tierra del Fuego, Navarino Island, and the CHBR. Note in the central box that the Diego Ramírez Islands are near the edge of the continental shelf. In each of the side boxes, yellow dots indicate the location of monitoring stations in terrestrial, freshwater, and coastal-marine ecosystems. Figure taken from Rozzi et al. (2020).

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Finally, in 2022 the Cape Horn International Center (CHIC) was inaugurated in Puerto Williams. The building was funded by the regional government of Magallanes, Chile. Built on a 2.2 hectare site in the city of Puerto Williams, the center's size is 2,581 square meters, and it has LEED (Leadership in Energy and Environmental Design) environmental certification. It will host the University of Magallanes and the Cape Horn International Center (funded by the Chilean Agency for Research and Development [ANID], part of the Ministry of Science, Technology, Knowledge and Innovation), and it is organized in three modules: (1) Technical and Higher Education, (2) Sustainable Tourism and Biocultural Conservation, and (3) Transdisciplinary Research (Figure 3).

Figure 3. Digital models of the Cape Horn International Center (CHIC) building in Puerto Williams, Cape Horn Biosphere Reserve, Chile. Top left, general view from the Beagle Channel. Top right, southeast view of the CHIC building fronts. Below, placement of CHIC's three modules in the final location and their objectives. N.d.

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Collaboration with regional, national, and international actors will allow the LTER-Cape Horn network and CHIC (Figure 4) to: (i) provide critical data, which will open up new opportunities for monitoring climate change and its impact on biodiversity and ecosystems in subantarctic latitudes; (ii) consolidate long-term monitoring, which is an essential component to effectively design mitigation and adaptation actions; (iii) strengthen a local sustainable development model that, in association with the CHBR, contributes from the south of the world to a biocultural conservation model that meets the needs of socio-economic well-being and environmental sustainability at multiple regional and planetary scales.

Figure 4. Photograph of the Cape Horn International Center (CHIC) building in Puerto Williams, on Navarino Island, Chile. Photograph by Camilo Quidel, May 2022.

Microcosm Macrocosm

The Skies as a Natural Laboratory

We could define a natural laboratory as a territory with unique natural characteristics that provides comparative advantages for the development of science and technology of high impact worldwide. In this definition, the word “territory” makes explicit reference to the importance of the place where the natural laboratory is located and its ecosystem, which, of course, includes the human and nonhuman beings who inhabit it.

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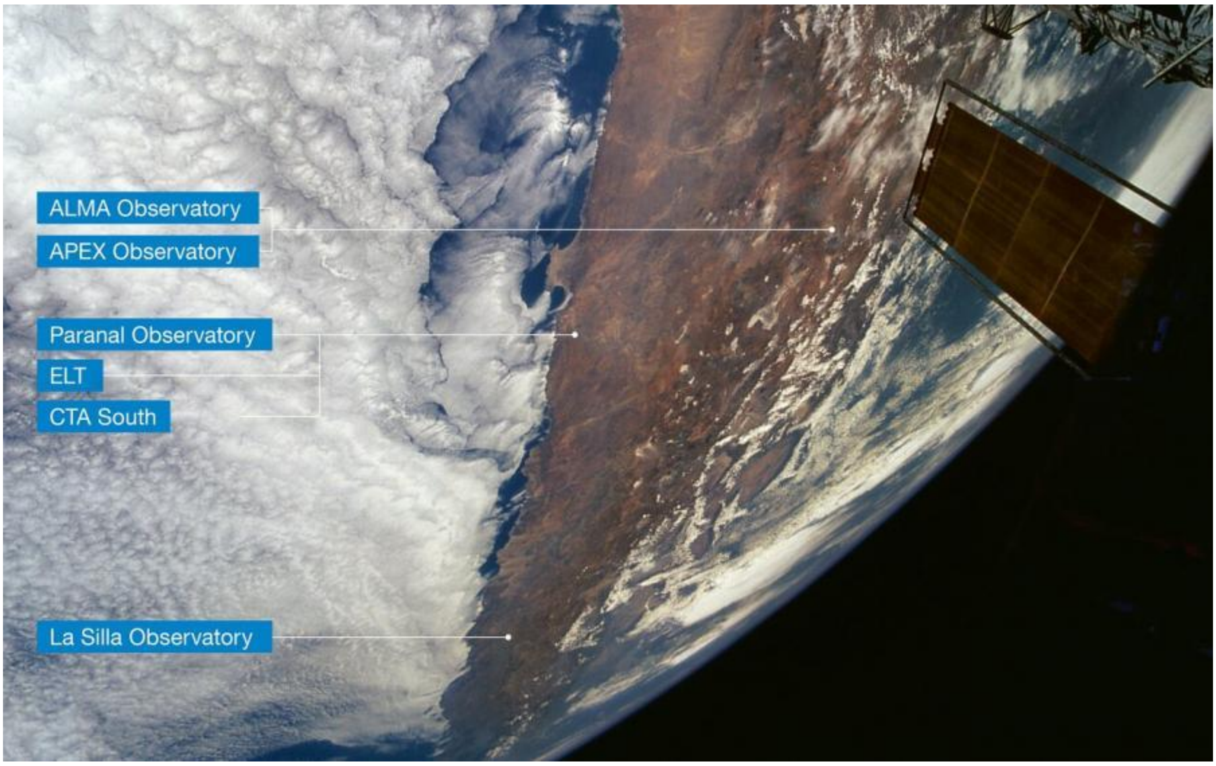

This view of northern Chile, as seen from the NASA Space Shuttle during a servicing mission to the Hubble Space Telescope (partly visible to the right), shows the Atacama Desert, where ESO's observatories are located. Northernmost is the Atacama Large Millimeter/submillimeter Array (ALMA) and the Atacama Pathfinder Experiment (APEX), two international observatories of which ESO is a partner. ESO's Paranal Observatory, home to ESO's Very Large Telescope and where the future ESO Extremely Large Telescope (ELT) and the south site of the Cherenkov Telescope Array (CTA) will be located, are a few hundred kilometers southwest of ALMA and APEX. The La Silla Observatory, ESO's first observatory, is even further south. Few clouds are seen in this extremely dry area, due to the influence of the cold Humboldt Current along the Chilean Pacific coast (left) and the high Andes mountains (right) that act as a barrier. Background photo courtesy of ESA astronaut Claude Nicollier, n.d.

Courtesy of ESO/Modified from original by Claude Nicollier.
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Chile is a privileged country. It has unique geographical conditions due to its great extension in latitude, combining factors such as climate, the height of the Andes mountains, and its coast of more than four thousand kilometers, accompanied in all its extension by the Humboldt Current and the sea that reaches great depths, particularly in the Atacama Trench. All this creates multiple geographical spaces or, rather, territories that can be qualified as natural laboratories, with the potential to be scenarios for the development of local science and research but addressing issues of global interest.

Among the natural laboratories that can be identified in Chile are: the sea, the northern skies, the desert, the mountains (and their minerals), and the subantarctic territory. Of these, it could be argued that the northern skies are one of the most advanced in terms of attracting great infrastructure and contributing to the scientific community. Since the arrival of the first observatories, almost 60 years ago, this natural laboratory has attracted international investment valued at more than eight billion dollars for the construction of the largest and most powerful telescopes in the world. The arrival of the observatories was also accompanied by a visionary public policy, which gives a percentage of the telescopes' observation time to researchers associated with Chilean institutions. This policy has fulfilled its purpose and managed to establish, over the years, a scientific community that grew from a couple of dozen people in 1990 to more than a thousand today, including students, professors, and postdocs in more than two dozen universities throughout the country (data from the census made by Sociedad Chilena de Astronomía [SOCHIAS] in 2021). This community, now mature, is also involved in the construction of part of the instrumentation for the observatories and is integrated into the international collaborations that have made discoveries of great importance in recent years. In addition, it can perform in leadership positions within the international scientific governance, both in the managing of the observatories and representing international institutions in Chile, thus carrying out the formal and diplomatic relationship with the host country, an important part of what we define as "astropolitics."

The original virtual exhibition features an interactive gallery of images.

View the images on the following pages.

On 2 July 2019, ESO's La Silla Observatory was host to a rare astronomical event, a total solar eclipse. Inaugurated in 1969, La Silla Observatory led ESO to the front line of astronomical science. The 50th anniversary celebrated La Silla's continued contribution to science, and coincided fortuitously with the shadow of the total solar eclipse, or umbra, passing over the site.

Captured in this image is the stunning view of the total solar eclipse, a rare event, which lasted for fewer than two minutes that day. During a total solar eclipse, the sun and moon cross paths in the sky, overlapping perfectly, a feat only possible because the sun and moon happen to be the right distance from Earth to take up the same portion of the sky.
A few stars shine bright for a moment while the sun's brilliant corona halos the moon, like shimmering strands of silk. A truly breathtaking experience, one that will not occur again at La Silla until the year 2231.
Photograph by Mahdi Zamani, n.d.
Courtesy of ESO/M. Zamani.
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A total eclipse of the moon is an impressive spectacle, but it also provides another impressive view: a dark, moonlight-free starry sky. At Cerro Paranal in the Chilean Atacama Desert, one of the most remote places in the world, the distance from sources of light pollution makes the night sky all the more remarkable during a total lunar eclipse. Interestingly, the moon, which appears above one of VLT's Unit Telescopes (UT2), was being observed by UT1 that night. UT1 and UT2 are also known as Antu (meaning "the sun" in Mapudungun, one of Chile's native languages) and Kueyen ("the Moon"), respectively.

Photograph by Yuri Beletsky, 2010.
Courtesy of ESO/Y. Beletsky.
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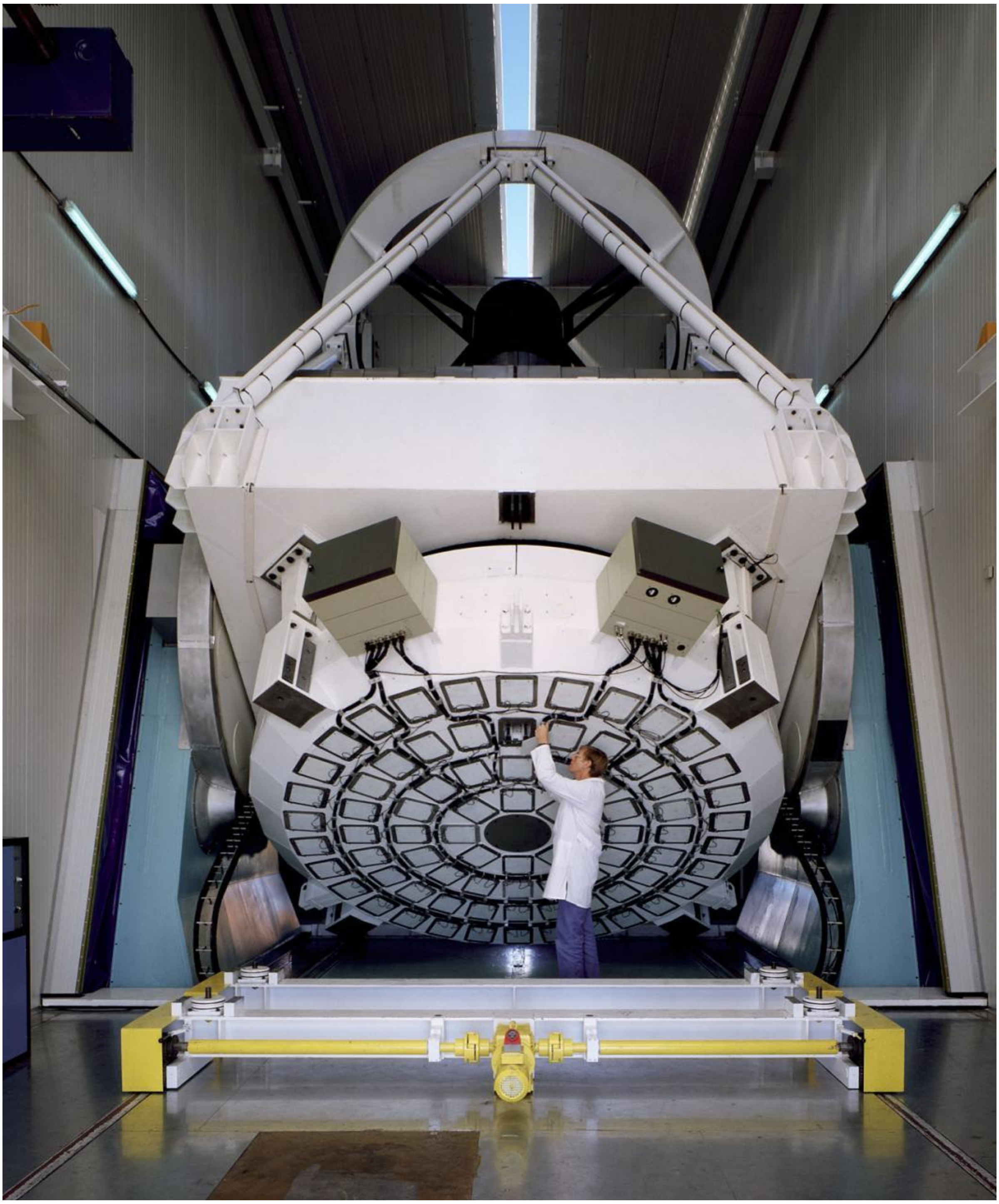

The New Technology Telescope (NTT) pioneered the active optics systems: its 3.56-meter diameter mirror is thin and flexible, and its shape is kept perfect thanks to the actuators supporting it.

Photograph by Claus Madsen, n.d.
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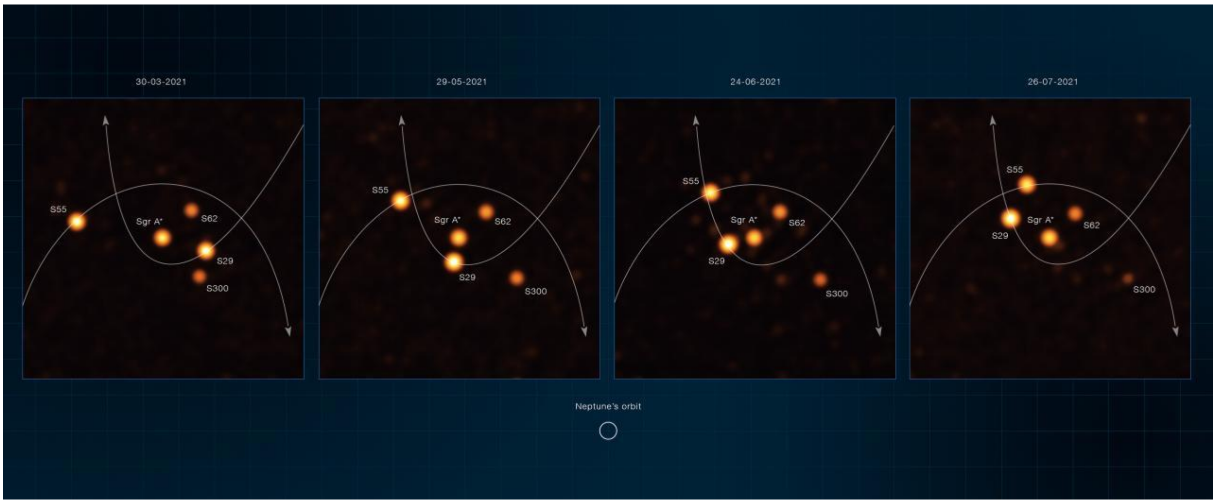

These annotated images, obtained with the GRAVITY instrument on ESO's Very Large Telescope Interferometer (VLTI) between March and July 2021, show stars orbiting very close to Sagittarius A*, the supermassive black hole at the heart of the Milky Way. One of these stars, named S29, was observed as it was making its closest approach to the black hole at 13 billion kilometers, just 90 times the distance between the sun and Earth. Another star, named S300, was detected for the first time in the new VLTI observations.

To obtain the new images, the astronomers used a machine learning technique, called Information Field Theory. They made a model of how the real sources may look, simulated how GRAVITY would see them, and compared this simulation with GRAVITY observations. This allowed them to find and track stars around Sagittarius A* with unparalleled depth and accuracy.

2021.
Courtesy of ESO/GRAVITY collaboration.
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However, the great potential of the natural laboratory can still be further developed in what may become its area of greatest impact: the social factor. The science developed around a natural laboratory is associated with externalities, which involve the interaction, services, or development of other areas. These include astrotourism, sustainable energy generation, the transfer and analysis of big data, technological innovation, and education, among other things, which can generate poles of local development, involving and benefiting the communities that inhabit the territory where the natural laboratory is located.

The European Southern Observatory (ESO) arrived in Chile in 1963 due to the unique atmospheric conditions in the north of the country, which, with more than 90 percent of clear nights per year and low atmospheric turbulence, offers some of the best places for astronomical observation in the world. During its almost 60 years of existence ESO has managed to become one of the leading institutions in the construction and operation of telescopes and astronomical research worldwide. ESO has developed technologies that allow for more precise observations in optical and infrared telescopes, enabling cutting-edge research and discoveries with worldwide recognition, such as the 2019 and 2020 Nobel Prizes in Physics (2019: Michel Mayor and Didier Queloz for discovering an exoplanet orbiting a solar-type star; 2020: Reinhard Genzel and Andrea Ghez for discovering a supermassive compact object at the center of our galaxy). In addition, ESO is currently building the largest optical and infrared telescope on the planet, the Extremely Large Telescope (ELT) on Cerro Armazones in Chile. All the above would not be possible without the existence of the natural laboratory of the northern Chilean sky. But, largely, this is due to the construction of a strong and close relationship with the host country, which we continuously try to support, looking for new paths that bring benefits from astronomy to society.

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This photo was obtained in mid-September 1994 and shows the work at Cerro Paranal on the foundations for VLT Unit Telescopes no. 1 (background) and 2 (foreground). Unknown photographer, 1994.

Courtesy of ESO.

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Construction of the world's biggest eye on the sky, ESO's Extremely Large Telescope (ELT), is making progress. After a significant slowdown of the building works due to the COVID-19 pandemic—including almost a year of complete site closure—works resumed in mid-2021. As this image from January 2022 shows, the foundations of the mammoth 39-meter telescope have been laid, taking us one step closer to uncovering some of the most elusive mysteries of the universe. Photograph by Gerhard Hüdepohl, 2022.

Courtesy of G. Hüdepohl (atacamaphoto.com)/ESO.
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Ecotourism with Hand Lenses and Astrotourism with Telescopes

Microcosm Macrocosm

What Do We Mean by "Ecotourism with a Hand Lens"?

In the beginning, human beings challenged their limits in face of unknown situations, traveling across continents and oceans in search of new territories and resources. Today, these initial motivations may have changed, and a large number of people spend their leisure time traveling in search of personal satisfaction and new experiences. In this way, tourism is not a static concept; it requires permanent innovation processes taking environmental and cultural changes into account. The search for novel experiences that feed human curiosity and allow the discovery of new landscapes and territories becomes an imperative in the contemporary construction of the tourist offer.

Starting in 2002, the work led by Ricardo Rozzi and the Fundación Omora team in the Cape Horn Biosphere Reserve (CHBR) set out to consolidate a new dimension in the valorization of the landscape, integrating ecological sciences with environmental ethics and revealing the diversity, functionality, and, without a doubt, the beauty of micro-landscapes or "miniature forests." For the global society of the twenty-first century, this activity awakens the curiosity of the human being to explore and value the microflora and invertebrates with which we cohabit in various ecosystems but which tend to go unnoticed due to their size (Figure 1).

Figure 1. “Ecotourism with a Hand Lens” is a special-interest tourism activity to appreciate the diversity, beauty, and ecological relevance of small organisms such as mosses. Photograph by Jaime Sepúlveda, Parque Omora, 2010.

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Figure 2. Graduate students practicing Ecotourism with a Hand Lens. Photograph by Adam Wilson, Omora Park, 2010.

At Cape Horn, the use of a magnifying glass or hand lens allows you to discover these micro-landscapes, generating a memorable experience of never-before-seen shapes, colors, and textures. According to the perspective developed by Ricardo Rozzi and the group of researchers that accompanies him, the idea—behind the concept of what is beginning to be called "Tourism with a Hand Lens" or better "Ecotourism with a Hand Lens"—is to interpret the landscape at its various scales and through a biocultural story, promoting a change in the understanding of the environment we inhabit. This activity provides a new way of doing slow tourism and was created in the Omora Park (Figure 2).

Omora Ethnobotanical Park: An Ideal Place for Ecotourism with a Hand Lens

The first formal experiences of Ecotourism with a Hand Lens were proposed in the early 2000s by an interdisciplinary group of ecologists, philosophers, and artists at the Cape Horn Miniature Forest Garden. This garden includes a network of two kilometers of trails and 20 interpretative stations at the Omora Ethnobotanical Park (Figure 3), situated along the Beagle Channel, in the vicinity of the southernmost city in the world, Puerto Williams. During this period, mainly of scientists, students, cruise travelers, institutional visitors, and members of the educational community of Cape Horn came as visitors to the Omora Ethnobotanical Park.

Figure 3a. Interpretive station on the Miniature Forests of Cape Horn trail at the Omora Ethnobotanical Park. Photograph by Adam Wilson, January 2010.

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Figure 3b. Interpretive station on the “miniature forests of Cape Horn” trail at the Omora Ethnobotanical Park. Photograph by Gonzalo Arteaga, January 2010.

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The Omora Park offers a sample of the high diversity of subantarctic bryoflora and protects *in situ* not only populations of mosses, liverworts, and lichens but also their ecological interactions with insects, fungi, bacteria, water, and soil. These interactions can be observed by visitors in their native habitats (Figure 4). The Omora Park is the first botanical garden dedicated to bryoflora with criteria of biocultural conservation, education, ecotourism, and field environmental ethics.

Ecotourism with a Hand Lens: A Unique Experience

In its more than 15 years of existence, Ecotourism with a hand lens has been characterized by allowing close contact with nature, based on observation, discovery, and reflection.

Figure 4. A mosquito midge dispersing spores of the moss *Tayloria mirabilis* on the interpretive trail of the “miniature forests” of Omora Park. Photograph by Adam Wilson, n.d.

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Aimed at educating visitors in their condition as coinhabitants of the planet, they allow us to appreciate the various forms of life and understand their systemic role in the habitat we share. In particular, tourism experiences with a magnifying glass consist of guided activities in small groups, slow, reflective, and developed in limited extensions of land, generating limited and controllable environmental impacts.

Figure 5. University of North Texas student Sean Connery during a Field Environmental Philosophy training course at Omora Park in 2010. Photograph by Adam Wilson, n.d.

Additionally, its scale and biocultural definition consolidate it as an alternative to mass tourism: this new form of tourism allows the incorporation of neighboring communities and favors local development, as well as the training of guides and specialized tourist service providers in local micro-forests, under the Field Environmental Philosophy approach designed in the Omora Park (Figure 5). Another characteristic of magnifying tourism is its ease of development along paths accessible to persons with disabilities, which implies low-mobility effort and the incorporation of a large population group, where the elderly and children play a predominant role when naming the species.

In the context of Field Environmental Philosophy, the ecotourism experience with a magnifying glass is intended to extend to different parts of the planet, without the need to deepen the carbon footprint; however for those who visit Patagonia or plan to visit the Antarctic continent, it is a great opportunity to complement your trip and live the experience in the Omora Ethnobotanical Park.

How Is Ecotourism with a Hand Lens Practiced?

To enjoy this experience, visitors are required to reach significant levels of concentration and have time to experience the textures and pigment tones of the foliage, or the movements of small invertebrates that emerge in the middle of the attractive micro-forest plot. This act, according to what was expressed by Ricardo Rozzi in 2005, also implies paying attention to observe ourselves, our breathing, emotions, and curiosity. In this way, an ethical and recreational ecotourism experience is achieved through informal education, deployed in plots of biological and cultural diversity.

Figure 6a. Ecotourism with a Hand Lens is a form of “slow tourism” that allows us to observe ourselves, with our breath, emotions, and curiosity, coinhabiting with mosses and other organisms. Photograph of Cristián Valle taken from Rozzi et al. (2010).

Figure 6b. Ecotourism with a Hand Lens is a form of “slow tourism” that allows us to observe ourselves, with our breath, emotions, and curiosity, coinhabiting with mosses and other organisms. Photograph of Cristián Valle taken from Rozzi et al. (2010).

The Propagation of Ecotourism with a Hand Lens

Throughout Chile, in addition to the Omora Park, one of the protected areas that has implemented Ecotourism with a Hand Lens experiences is the Altos de Cantillana Reserve, located south of the Santiago Basin in the central zone of Chile. This area corresponds to a global biodiversity hotspot of Mediterranean flora and presents varied ecosystems, among which the sclerophyllous forest, the deciduous oak forest of Santiago, and the relict High Andean scrub from the last glaciation stand out. On the Big Island of Chiloé and in the Chilean Lake District, it has been implemented in private protected areas, such as Los Senderos de Chepu and Reserva Huilo-Huilo. Recently, the regional government of Aysén adapted the methodology of the Omora Park in a training program called “Ecotourism with a Hand Lens: Bryophytes, Lichens and Freshwater Macroinvertebrates” in Queulat National Park.

Figure 7. An Ecotourism with a Hand Lens exhibition focused on mosses and art at Shenzhen Fairy Lake Botanical Garden, Shanghai. Photograph by Li Zhang in Zhu, 2018.

At an international level, tourism with a hand lens was adapted in 2012 in Bangor, Wales, United Kingdom as well as in an exhibition at the Shenzhen Fairy Lake Botanical Garden in Shanghai, China in 2014. However, as the botanical garden in Shanghai is not a natural reserve, this experience is with cultivated mosses. In Germany, in 2006, a "moss garden" was inaugurated in the Berlin Botanic Garden and Botanical Museum, which invites visitors to discover it through lenses and magnifying glasses. Finally, since 2021 there has been an active collaboration between Ricardo Rozzi and his team and Senckenberg Museum in Frankfurt.

Benefits of Ecotourism with Hand Lenses

Understanding Ecotourism with a Hand Lens implies valuing the curiosity of the human being. Viewing a landscape magnified through a lens, visitors discover and appreciate an exuberant diversity of life forms. For example, they stop at the unknown distinctive features of the microflora: mosses, liverworts, hornwigs, and lichens. One of its advantages is that it takes place in a relatively small space, where various species can be explored. In this way, micro-landscapes are related to landscapes commonly known as gardens and squares (Figure 8). In particular, the research carried out by Ricardo Rozzi and Alejandra Tauro in 2023 allows us to identify the didactic value of this form of observation, which is to recognize the importance of small beings in nature. The discovery and observation of these beings, which were previously "invisible" to most of the visitors, creates awareness of how little we know about our environment, and invites us to act more cautiously. In this context, in 2010, Rozzi and other authors indicated that Ecotourism with a Hand Lens represents an ethical practice that contributes to a respectful cohabitation in the biocultural diversity in which we are immersed.

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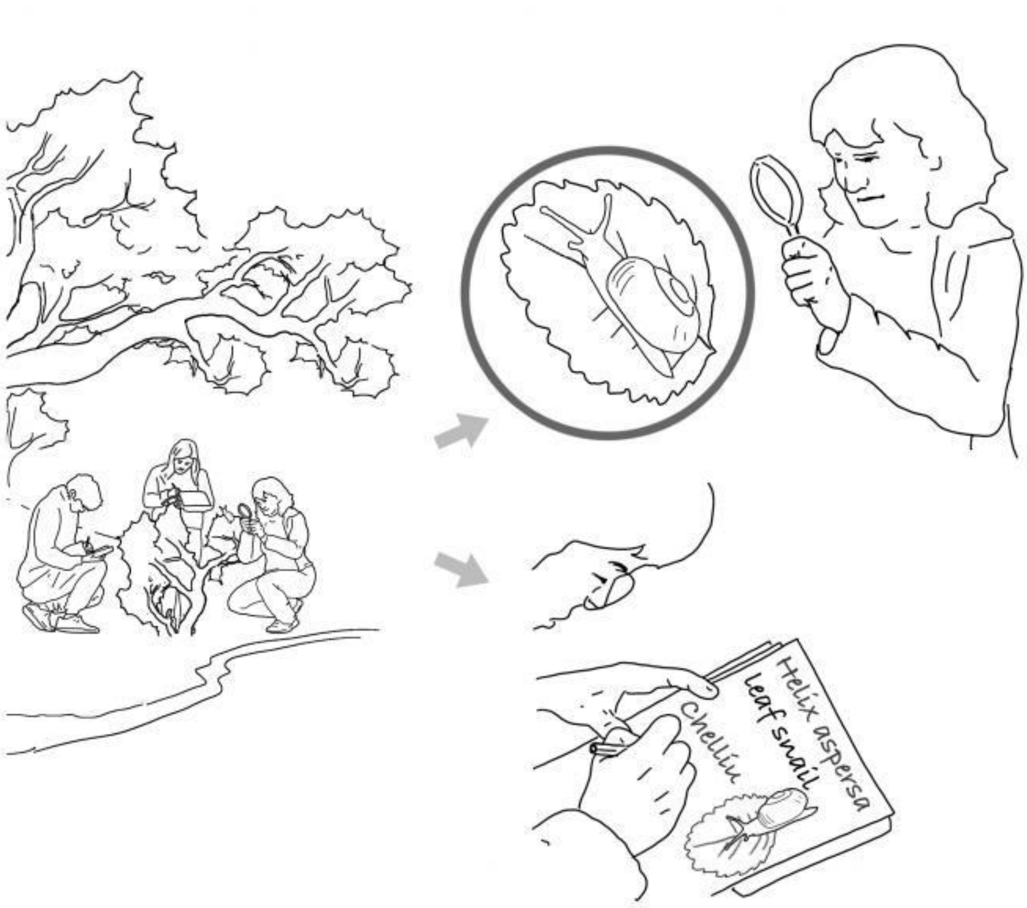

Figure 8. Scheme to illustrate that the experience of Ecotourism with a Hand Lens involves the active participation of visitors in, for example observing, drawing, and naming mosses. This activity can be practiced in everyday habitats, such as gardens, parks, or schoolyards. Illustration by Mauricio Álvarez, adapted from Rozzi and Tauro (2023).

Microcosm Macrocosm

What Do We Mean by Astrotourism?

The relationship between traveling and observing the sky is deeply rooted in the curious essence of the human being. This is how systematic stellar observation, together with the technological development of navigation instruments, allowed the first travelers to trace and travel new routes, circumnavigate continents, travel seas and oceans, all over the world.

Figure 1. Naked-eye celestial observation as an introduction to astronomical observation, taking advantage of the quality of the skies of the Commune of Combarbalá, Cruz del Sur Observatory. Unknown photographer, n.d.

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Curiosity for the unknown is the meeting point between astronomy and tourism, giving shape and meaning to what we know as astrotourism, a tourist practice associated with recreational and educational experiences that bring the traveler closer to the observation and understanding of astronomical phenomena and of the cosmos. Astrotourism is also known as celestial ecotourism or star tourism.

In relation to the motivations for the development of this type of tourism, currently more than 80 percent of the world's population lives under skies polluted by artificial lights, and a third cannot see the Milky Way at night. The lack of access to the stars makes the urban dweller move away from the rhythms of nature and the universe. Therefore, being able to enjoy a sky free of light pollution has become a desire for many people, who are finding through astrotourism a formula to rediscover the emotion of looking toward the sky and observing the true spectacle that the firmament offers us (Figure 1).

Who Practices Astrotourism?

The growing awareness of the imperative need to guarantee preservation of the planet's biodiversity through greater knowledge and environmental and cultural protection connects with deep motivations based on leisure and the creation of dark skies for the enjoyment of starry nights, and with motivations related to cultivating a greater knowledge of the sky, celestial objects, and every cultural aspect related to them. In this way, more and more travelers attest that the observation and understanding of the cosmos are one of the elements that motivate the selection of tourist destinations, activities, and experiences.

Those interested in astrotourism, depending on the provision made by the "sky" as a resource to satisfy the need for travel, can be basically broken down into two large groups of people: amateur astronomers and the general public.

Astrotourism in Chile

Northern Chile in particular is a unique natural laboratory for observing the cosmos for astronomical purposes. Thanks to the transparency of its skies, 40 percent of the world's astronomical observations are made in Chile, and according to estimates this could reach 70 percent in the coming years. In this sense, if the tourist activity is characterized by offering visitors new, unique, and memorable experiences, the opportunity to observe the sky from Chile becomes, in itself, an opportunity impossible to replicate anywhere else on the planet.

Figure 2. The astronomical facilities are a great visitor attraction; in the image you can see a guided tour of the Cerro Paranal Observatory. Unknown photographer, n.d.

This differentiation substantially increases the territorial valuation and allows the positioning of Chile at the forefront of world astronomical tourism (Figure 2). For example, in 2015, the International Dark Sky Association (IDA) declared the astronomical site of the AURA Observatory in the Elqui Valley the first International Dark Skies Sanctuary in the world. In this way, astrotourism in Chile takes advantage of the more than 300 clear nights a year and the low light pollution in the north of the country to gaze at the stars through some of the most powerful scientific observatories in the world.

How Astrotourism experiences are developed in Chile

In particular, two studies that analyze the dynamics of astrotourism in Chile for both national and international tourists (CORFO, 2016a, b) identify the main activities that attract tourists linked to celestial observation as: visiting scientific observatories and visiting parks or nature reserves to observe the night sky, eclipses, and other celestial phenomena. An example of this could be seen on 2 July 2019, when one of the most important astronomical events in the world was experienced: the total solar eclipse. This phenomenon made more than three hundred thousand people come to the regions with the best conditions for its observation, offering the people who witnessed it from our country a unique tourist attraction.

Figure 3. Ideal equipment for visitors to develop high-resolution photographs of the sky and its stars through astrophotography, El Pangue Observatory, Vicuña Commune. Unknown photographer, n.d.

Juárez Alcázar distinguishes five types of astrotourism experiences: sky interpretation sessions, visits to research facilities, astronomical viewpoints, planetariums, and g-astronomy (astronomy-themed gastronomy). However, the diversification of experiences around astrotourism goes beyond observing the sky through a lens, telescope, or screen.

From the observation and interpretation of the sky with the naked eye to local guides who explain the ancestral understanding of the sky over virtual tourism that allows visitors to remotely access a telescope located in the Atacama Desert, astrotourism offers an opportunity to design innovative tourism products with extensive options to incorporate local communities trained in visitor care.

Among these activities in Chile are: the option to enjoy overnight stays under starry skies and astrophotography (Figure 3) in the Elqui Valley; gastronomy inspired by the sky and the traditions of the original peoples; archaeoastronomy and astromusic in San Pedro de Atacama; hiking and horseback riding for contemplation at night, mainly on full moon nights, in the valleys of Santiago; thermalism in the light of the stars in the Tarapacá region; and also innovation such as gamification or "starparties," crafts inspired by the sky, ancestral celestial baths, etc.

It is encouraged that these unique experiences are developed within the framework of sustainability, motivating service providers to join the Sustainability Seal and travelers to schedule long-stay trips and offset their carbon footprint, to mitigate the effects of tourism on climate change.

Main Destinations and Astrotourism Experiences in Chile

Astrotourism can be practiced throughout Chile, and in particular between the regions of Antofagasta and Coquimbo in the tourist destinations of La Serena, Valle del Elqui, San Pedro de Atacama, and Antofagasta. It is possible to find agencies that are responsible for transporting and providing accommodation and equipment and interpretation for stargazing.

Figure 4. An interesting observatory built especially to welcome visitors and stimulate the development of tourism in the town of Andacollo. If you go inside, it is possible to see the stars from a telescope that emerges from a dome. Collowara, Andacollo, Chile. Unknown photographer, n.d.

The interest in opening up astronomical activity to tourism has led municipalities, foundations, and the wider public to build and make available to establish what is called "Tourist Astronomical Observatories" (Figure 4). In 2018 the registered number of observatories destined exclusively for tourist and educational purposes throughout Chile amounted to 35, 4 of which are located in the Antofagasta Region, 1 in the Atacama Region, 15 in the Coquimbo, 2 in the Valparaíso Region, 5 in the Santiago Metropolitan Region, 2 in the O'Higgins Region, 1 in the Maule Region, 4 in the Biobío Region, and 1 in the Los Lagos Region.

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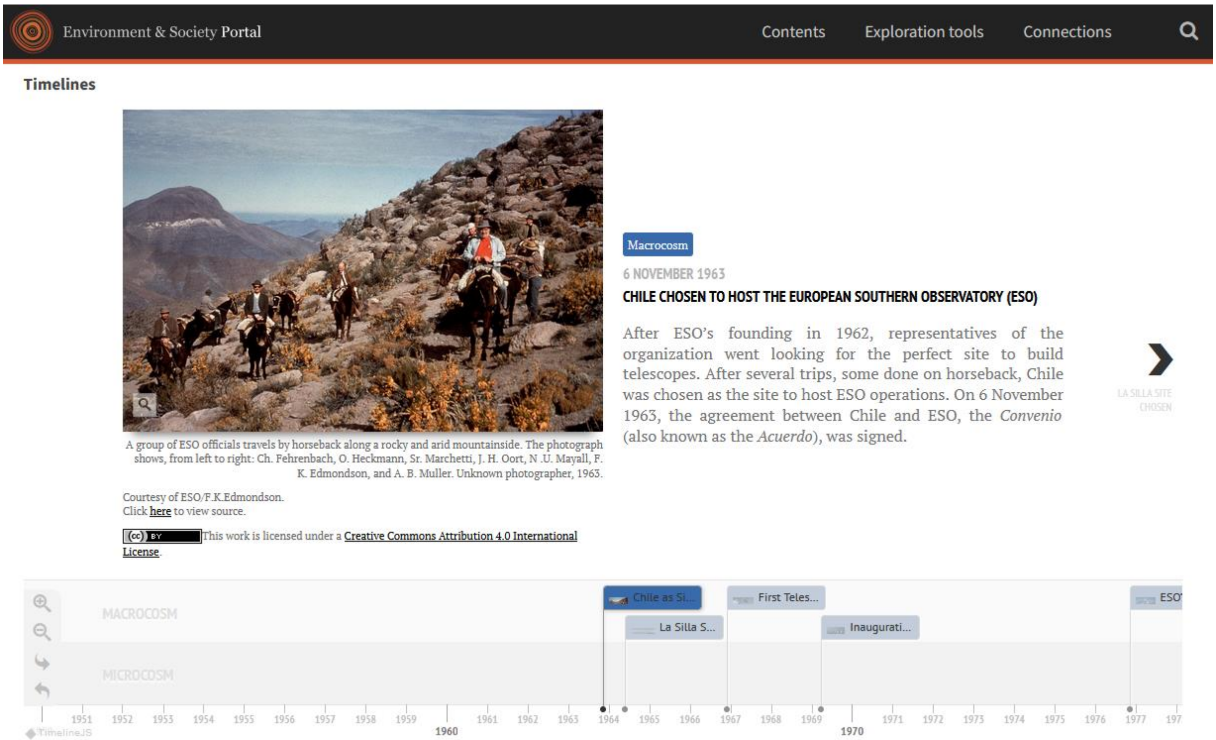
Timelines

The original virtual exhibition features an interactive timeline on the developments of the macrocosm and microcosm. Visitors can browse the timeline chronologically or by one of the two perspectives in the exhibition. Read an offline version of the timeline on the following pages or visit the online version here (https://www.environmentandsociety.org/exhibitions/hand-lenses-telescopes/timeline/vehandlensestimeline)



Screenshot of the Timeline for *From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories*

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
Chapter: Timelines
PDF created on: 7 June 2023 17:30:43

Chile Chosen to Host the European Southern Observatory (ESO)

Timeline: Macrocosm

6 November 1963

After ESO's founding in 1962, representatives of the organization went looking for the perfect site to build telescopes. After several trips, some done on horseback, Chile was chosen as the site to host ESO operations. On 6 November 1963, the agreement between Chile and ESO, the *Convenio* (also known as the *Acuerdo*), was signed.

A group of ESO officials travels by horseback along a rocky and arid mountainside. The photograph shows, from left to right: Ch. Fehrenbach, O. Heckmann, Sr. Marchetti, J. H. Oort, N .U. Mayall, F. K. Edmondson, and A. B. Muller. Unknown photographer, 1963.

Courtesy of ESO/F.K.Edmondson.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/eso0912d/

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Chapter: Timelines
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La Silla Site Chosen

Timeline: Macrocosm

25 May 1964

The ESO Council selects the mountain Cinchado Nord—later to become La Silla Observatory—as the first site to host ESO telescopes.

This photograph of La Silla was taken by Otto Heckmann (1901–1983), ESO's inaugural director general, on the occasion of his first landing on La Silla in April 1964. Photograph by Otto Heckmann, 1964.

Photograph by Otto Heckmann, 1964.
Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

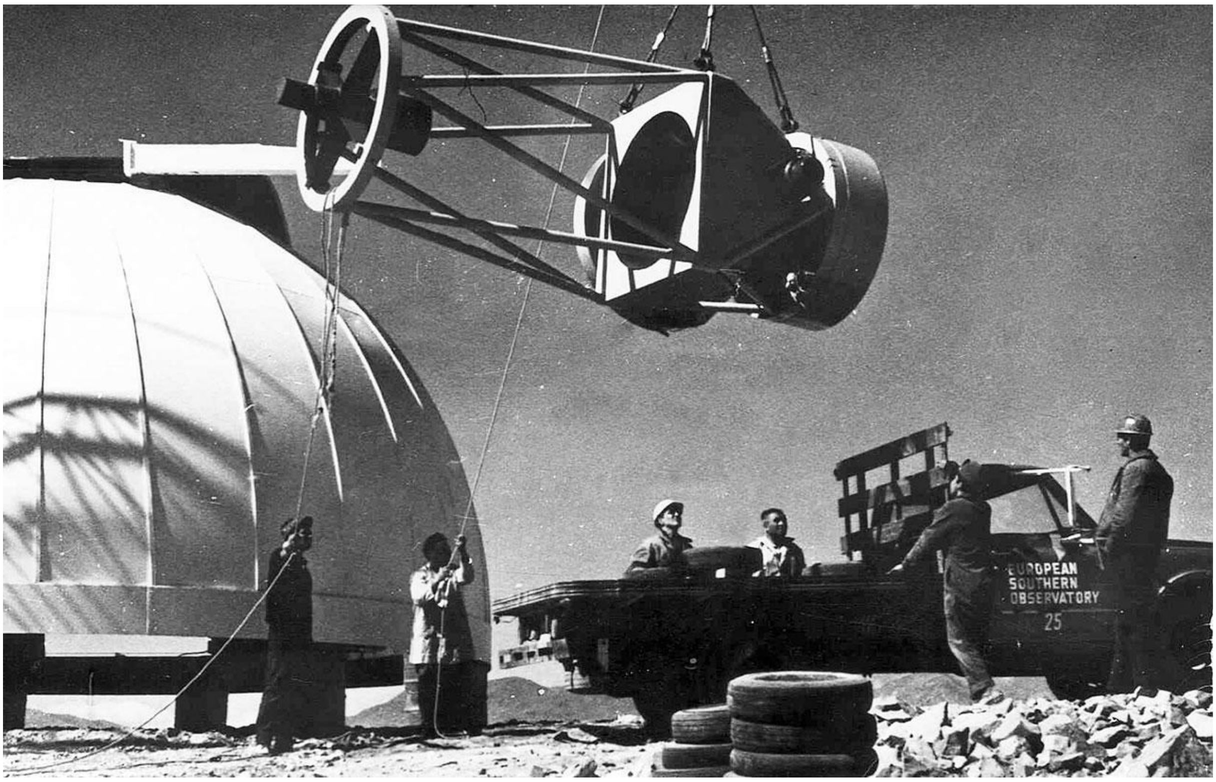
https://www.eso.org/public/images/la/

The First Telescope

Timeline: Macrocosm

30 November 1966

The first telescope to be built at La Silla in Chile was ESO's one-meter telescope. In late 1966, the telescope had its first light. The telescope made many important discoveries linked to stars in the Milky Way, stellar clusters, and, in our closest neighboring galaxies, the Magellanic clouds.



This photo illustrates the delivery of ESO's one-meter telescope to the new La Silla observatory. Unknown photographer, n.d.

Courtesy of ESO/J.Doornenbal.
Click here to view source.

Websites linked in image captions:

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Inauguration of La Silla

Timeline: Macrocosm

25 March 1969

The La Silla Observatory was inaugurated on 25 March 1969 by the president of Chile, Eduardo Frei Montalva, in the presence of numerous representatives from politics and science. A few days earlier, on 21 March 1969, the ESO's Chilean headquarters had been opened in Santiago's Vitacura district.

This photograph shows the front row of guests during the opening ceremony of the La Silla Observatory. From left to right: Otto Heckmann (director general of ESO), Gabriel Valdes Subercaseaux (minister of foreign affairs of Chile), Olof Palme (minister of education of Sweden), Eduardo Frei Montalva (president of the Republic of Chile), and Jan Hendrik Bannier (president of the ESO Council). Unknown photographer, n.d.

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/lso_inauguration_03-69_2/

First Light for ESO's 3.6-meter Telescope

Timeline: Macrocosm

7 November 1976

First light of ESO's 3.6-meter telescope at La Silla was achieved on 7 November 1976. The telescope is still to this day (2023) in active use, hunting for planets outside of our solar system.

In this image from the 1970s, the domes of ESO's one-meter telescope (front) and 3.6-meter telescope (back) can be seen. Unknown photographer, 1973.

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/ehpa-10-1973-lso-view/

First Light for the NTT

Timeline: Macrocosm

23 March 1989

The first light of the ESO New Technology Telescope (NTT) at La Silla, a telescope still in active use, was achieved on 23 March 1989. Its mirror is flexible and deformable, allowing it to be adjusted by actuators during observations, using a reference star, to preserve the optimal image quality. This technology is known as active optics and was developed by ESO. It broke new ground for telescope engineering and design and is now applied to all major modern telescopes.

The New Technology Telescope (NTT) at La Silla Observatory in Chile. Unknown photographer, n.d..

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

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Cerro Paranal Chosen for the VLT

Timeline: Macrocosm

4 December 1990

In December 1987, the ESO Council made the decision to build the Very Large Telescope (VLT). Less than one year later, the Chilean government donated the land around Cerro Paranal in the Chilean Atacama Desert to ESO. On 4 December 1990, this land was chosen to be the home for the VLT. In September 1991, the construction of Paranal Observatory began with leveling of the 2,690-meter mountaintop to 2,650 meters, to fit the platform for the upcoming telescopes.

An aerial view of Mount Paranal, the proposed site for the Very Large Telescope (VLT). Unknown photographer, 1994.

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

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Widening the Agreement

Timeline: Macrocosm

18 April 1995

At ESO Headquarters in Germany, the director general of ESO, Professor Riccardo Giacconi, and Roberto Cifuentes, ambassador representing the government of the Republic of Chile, signed a Supplementary, Interpretative, and Amending Agreement to the Convention of 6 November 1963. This agreement represented a significant widening and strengthening of the cooperative relations between ESO and the Chilean scientific community. At this time, construction of the VLT was progressing at Paranal.

This image depicts the VLT construction site on Paranal from an altitude of about 3,000 meters. Unknown photographer, n.d.

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

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First light of the VLT

Timeline: Macrocosm

12 April 1998

The first light for the VLT's first 8.2-meter Unit Telescope (UT1), Antu, was achieved on 12 April 1998. This was a great milestone, and at the time, the UT1's sensitivity for point sources such as stars was superior to any previously achieved by existing telescopes on Earth. Later, in September of the same year, the FORS instrument at the telescope had its first light, capturing a spectacular image of the spiral galaxy NGC 1232.

This image of the large spiral galaxy NGC 1232 was taken by the VLT on 21 September 1998.

Courtesy of ESO.
Click here to view source.

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Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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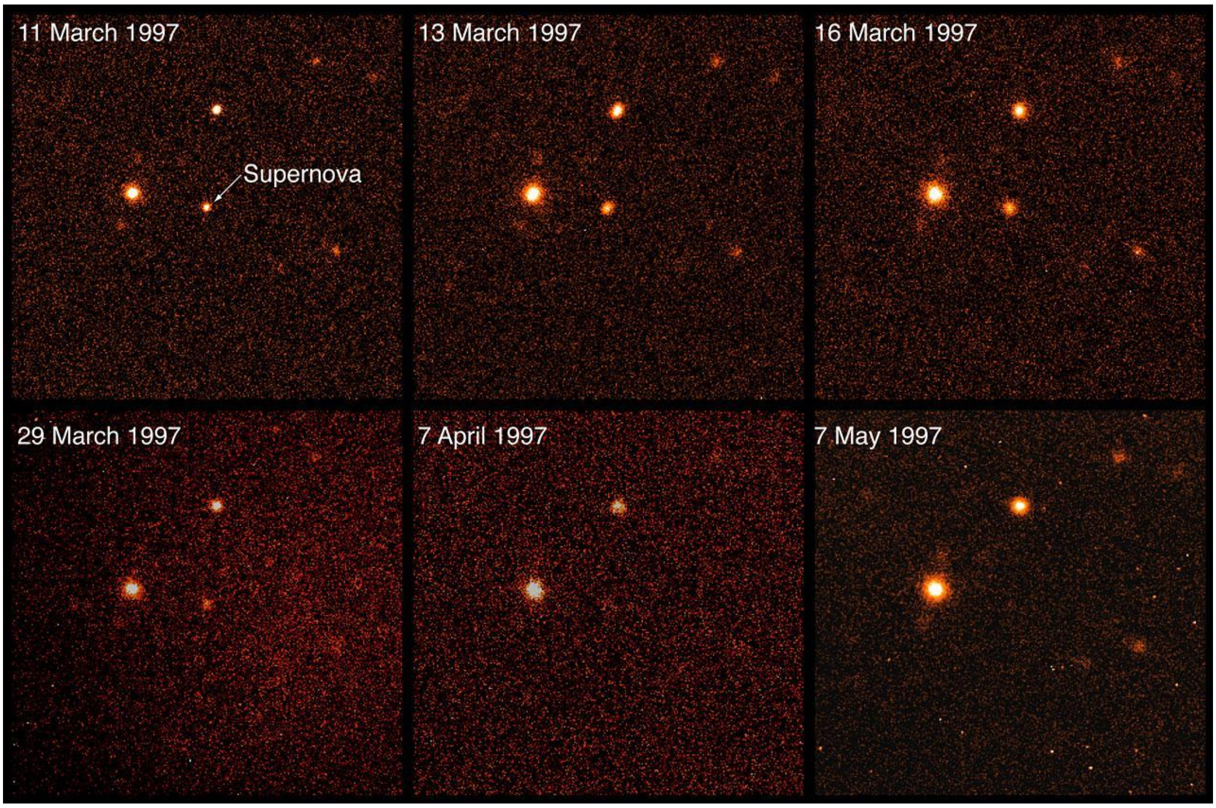
The Accelerating Universe Revealed

Timeline: Macrocosm

15 December 1998

Two independent research teams, with work partly based on observations of exploding stars (supernovae) with astronomical telescopes at La Silla, showed that the expansion of the universe is accelerating. The 2011 Nobel Prize in Physics was awarded for this result.



In this image, it can be seen that the supernova is becoming dimmer and it is accelerating away from us.

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/eso9861b/

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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Creation of the Omora Ethnobotanical Park

Timeline: Microcosm

2000

This Subantarctic Natural Laboratory has been conceived as a physical and conceptual space to provide education experiences, conduct biodiversity research, and protect the Róbalo River basin through a concession from the Ministry of National Assets granted to the University of Magallanes and the Omora Foundation.

The Omora Park has three main purposes:

1. Research: A natural laboratory to study the ecology and biocultural diversity of the planet's southernmost forests, and impacts of global change in the Cape Horn Biosphere Reserve (CHBR).
2. Education: An outdoor classroom open to schools, university students and teachers, and interested visitors.
3. Conservation: A protection area for the Róbalo River basin and a priority site for the conservation of biodiversity in Chile.

Entrance to the Omora Ethnobotanical Park in autumn. Photograph by Omar Barroso, n.d.

First Field Environmental Philosophy Workshop

Timeline: Microcosm

2000

In 2000 a group of scientists, artists, philosophers, and other professionals, both Chilean and foreign, created a novel educational methodological approach to appreciate local biocultural diversity. This methodology is called "field environmental philosophy" (FEP). FEP integrates sciences, humanities, arts, and ethics to learn about biophysical, symbolic-linguistic, and political dimensions of biocultural diversity. The integration of biophysical, conceptual, and institutional dimensions has been successfully implemented in graduate curricula of the University of Magallanes in Chile and the University of North Texas in the US, as well as other universities in Latin America and on other continents. Although developed in the remote Cape Horn region, the FEP methodological approach can be practiced in urban and rural areas worldwide. To incorporate FEP into graduate programs, an interrelated four-step cycle was designed:

Step1: Transdisciplinary ecological and philosophical research.
Step 2: Poetic communication through the composition of metaphors and narratives.
Step 3: Design of guided field activities with an ecological and ethical orientation.
Step 4: Implementation of *in situ* conservation.

Temas

El Magallanes, domingo 16 de enero de 2022 / 23

Participantes del Taller de Filosofía Ambiental de Campo interactúan tras dibujar el área en laguna Zañartu.

La filosofía ambiental de campo y los desafíos de la educación en las experiencias en la naturaleza

Educadores e investigadores vivieron la experiencia de la innovadora metodología implementada en Reserva de la Biosfera Cabo de Hornos

Fotos Rolando Martínez

Tomar la lupa y observar pequeños musgos que crecen en medio de troncos de la vegetación de lengas, coigües o ñirres es uno de los ejercicios realizados al interior del Parque Etnobotánico Omora, en Puerto Williams, por una treintena de participantes entre investigadores y académicos que participaron en el Taller de Filosofía Ambiental de Campo que en los veranos promueve el Programa de Conservación Biocultural Subantártica con el apoyo de la Universidad de Magallanes, y la Universidad de North Texas, además el auspicio de la Embajada de Estados Unidos en Chile, Agencia Nacional de Investigación y Desarrollo de Chile (Anid), Centro de Tecnología de Excelencia Cape Horn International Center y Fundación Omora.

Filosofía ambiental

Este año la iniciativa se retomó, tras un receso obligado del verano de 2021 por la pandemia, y al respecto el académico de ambas universidades, Ricardo Rozzi, precisa que la filosofía ambiental para el ciudadano común alcanza dos aspectos fundamentales.

"Uno, la educación de los hijos va a ser distinta. La educación no será sólo por medios que el profesor le dice todo y que son por medios puramente computacionales, que se mantienen y son valiosos, pero tendrá la experiencia de salir a la plaza, a la precordillera y tendrá elementos para el propio niño de ir descubriendo como son los componentes de los ecosistemas, cómo se ordenan, cuáles son los procesos ecológicos, cómo son los distintos modos culturales de valorar y comprender la relación sociedad-naturaleza".

Acceso al Parque Omora.

Uno de los grupos participantes del taller en el circuito creado en el Parque Omora.

Y agrega que un segundo aspecto es para la sociedad porque esto propone un nuevo turismo, un turismo que es lento, muy acorde al post covid, y ese turismo que es lúdico donde se interactúa con el turista.

"En un espacio pequeño empieza a descubrir las maravillas de Magallanes con los líquenes, los musgos, las aguas más limpias, las hojas de los árboles, disfruta y se queda más tiempo. Es un turismo distinto que metafóricamente lo hemos llamado ecoturismo con lupa que es la expresión hacia esta filosofía ambiental de campo", señala el ecólogo Rozzi desde el interior del parque Omora que aún no ha podido reabrir sus puertas al público por la pandemia.

Este evento también es apoyado por el programa del Centro Subantártico Internacional Cabo de Hornos que será inaugurado durante el presente año en la comuna de Cabo de Hornos.

CIENCIA, FILOSOFÍA Y ARTES SE UNEN

El ecólogo y filósofo Ricardo Rozzi, principal relator del Taller de Filosofía Ambiental de Campo, explica que ésta es una metodología nueva para integrar la ciencia, la filosofía y las artes y dentro de la filosofía la ética y es en el campo, en el terreno, donde se ha trabajado.

"A diferencia de otros años este año es un taller de maestros, es decir de formadores", destaca Rozzi, quien detalla que entre los participantes están Lorena Medina, ex decana de la Facultad de Educación de la Universidad Católica y directora alterna del Centro Cabo de Hornos; Andrea Valdivia, directora del Instituto de Comunicación e Imagen de la Universidad de Chile; Laura Luna, antropóloga y profesora asociada del campus Villarrica de la Universidad Católica; Andrea Pino, directora del Centro Transdisciplinario de Estudios Ambientales y Desarrollo Humano Sostenible de la Universidad Austral de Chile; y Jessica Sepúlveda, académica del Centro de Etica Ambiental de la Universidad Católica de Temuco, entre otros para participar en este taller que les entrega nuevas metodologías para replicar.

Durante las primeras dos jornadas los participantes se dividieron en tres grupos para recorrer los senderos del Parque Omora y han dibujado paisajes, han palpado las hojas de especies arbóreas como coigüe, lenga, ñirre y canelo; han observado diminutos detalles con la lupa y se les ha desafiado a conectarse plenamente con la naturaleza en la que habitan aves, vegetación, pequeños musgos, líquenes e insectos.

También recorrieron el sendero del cerro La Bandera y trabajaron con lupas observando los bosques en miniatura y las especies que habitan bajo el agua en el río Róbalo, en un trabajo dirigido por la investigadora Tamara Contador, encargada de Investigación del programa en Puerto Williams.

International Field Environmental Philosophy courses have been conducted annually at Omora Park since January 2000. This article in *La Prensa Austral* from January 2022 illustrates the course offered that year.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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Recognition of the Subantarctic Magellanic Ecoregion as a Global Hotspot for Bryophyte (Mosses, Liverworts, and Hornworts) and Lichen Diversity

Timeline: Microcosm

2001

In 2001, Omora Park researchers discovered the high species richness and endemism of bryophytes or non-vascular flora in the Cape Horn Biosphere Reserve (CHBR), and more broadly in the subantarctic Magellanic ecoregion. These high levels of diversity and endemism were overlooked prior to the Omora Park research initiative and gained attention worldwide because, in contrast with other forests of Latin America, the species richness of vascular plants is much higher than that of non-vascular plants.

LATERCERA Domingo 13 de mayo de 2012 — 57

Tendencias

Estudio de la U. de North Texas, el Instituto Cary de EE.UU. y la U. de Magallanes, recién publicado en la revista Bioscience, analiza las características exclusivas de la zona: una gran biodiversidad, la reserva de agua dulce más grande fuera de la Antártica y el área más extensa de humedales templados del hemisferio sur, entre otras.

Por ***Francisco Rodríguez***

Las 10 razones de la ciencia para declarar al sur de Chile como lugar único en el mundo

1 Geografía única
Posee la mayor cantidad de tierra entre la latitud 40º sur (Valdivia) y 60º (Cabo de Hornos) del planeta.

2 Zona prístina
Es una de las 24 últimas zonas prístinas del planeta (según la ONG Conservation International).

70% de su cubierta vegetal está conservada.

Tiene zonas de 10.000 km2, que carecen de conectividad terrestre y desarrollo industrial y urbano.
Alberga la menor densidad poblacional en latitudes templadas con 0,14 habitante por km2.

3 Bosques
Es el área más extensa de bosque templado lluvioso del hemisferio sur.

Distribución
Argentina: 2 millones de hectáreas
Chile: 13,6 millones de hectáreas

TOTAL
15,6 millones de hectáreas, la extensión más grande de árboles de hoja perenne y bosque templado caducifolio (que pierden su follaje durante una parte del año) del hemisferio sur.

4 Humedales
Es el área más extensa de humedales templados del hemisferio sur. Los bosques subantárticos magallánicos están integrados a turberas (humedal ácido), pantanos, ciénagas y cojines conocidos como el Complejo de Tundras de Magallanes, que cubren 4,4 millones de hectáreas.

5 Biodiversidad
Tiene la mayor diversidad biológica mundial en plantas no vasculares y muchas de sus especies son endémicas.

% DE ESPECIES ENDEMICAS
90% Arboles
60% Flora
60% Musgos
FAUNA
80% Anfibios
50% Peces
36% Reptiles
33% Mamíferos
30% Pájaros

6 Agua limpia
No hay aguas de lluvia ni cursos de agua dulce más limpios en todo el planeta.
La zona está situada fuera de las corrientes de aire que transportan los contaminantes industriales y recibe las tormentas que se originan en el sur del océano Pacífico. El agua lluvia tiene muy pocos químicos. Un estudio de 2000 reveló que tienen las concentraciones de nitrato más bajas del mundo.

7 Reserva de agua
Posee las mayores reservas de hielo y agua dulce fuera de la Antártica: los Campos de Hielo Patagónicos y cordillera Darwin. Además, contiene vastas áreas de hielo continental: 4.200 km2 en los Campos de Hielo Patagónico Norte y 13.000 km2 en los Campos de Hielo Patagónico Sur. A esto se suman 2.300 km2 en glaciares.

8 Areas protegidas
Son las áreas protegidas no tropicales más extensas del hemisferio sur. El Parque Nacional Bernardo O'Higgins es el segundo más grande de América Latina (3,5 millones de há.). Si se suman las reservas y otros parques, se llega a 7,3 millones de ha, el territorio protegido continuado más grande de las latitudes no tropicales del hemisferio sur.

9 Diversidad cultural
Habita una gran diversidad de culturas vivas y lenguajes originarios, como los lafkenches, huilliches, pehuenches y yaganes.

10 Lugar histórico
Pieza esencial para entender el cambio climático. Resume la historia glacial desde el cuaternario (hace 2.500 millones de años) y registros palinológicos (polen y esporas).

Fuente: U. de North Texas, Cay Institute, U. de Magallanes. Fotos: Jordi Plana, Silvina Ippi, Adam Wilson, T. Torres y Ricardo Rozzi.

Francisco Solorio • LA TERCERA

Article in *La Tercera* newspaper illustrating the ten unique attributes identified for the subantarctic Magellanic ecoregion.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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Ecotourism with a Hand Lens

Timeline: Microcosm

2001

In 2001, long-term botanical fieldwork in the region disclosed that the subantarctic Magellanic ecoregion hosts more than five percent of the world's species of non-vascular plants. The Omora Park research team created the activity of "Ecotourism with a Hand Lens" to help citizens and decision-makers discover the beauty, diversity, and ecological importance of a flora that regularly goes unnoticed. "Ecotourism with a Hand Lens" enables policymakers, tourists, educators, and the general public to admire the exuberant diversity of little plants and lichens. This slow-tourism activity also summons ethical, aesthetical, and ecological values that broaden the perspectives that prevail in the relationship of global society with nature and reconnect citizens with the wonders of biocultural diversity.

EL MERCURIO

Vida • Ciencia • Tecnología

SANTIAGO DE CHILE, MARTES 13 DE NOVIEMBRE DE 2012

Bosques en miniatura:

Ecoturismo con lupa revela impresionante biodiversidad vegetal en isla Navarino

Al sur del canal Beagle se encuentra una de las más diversas poblaciones de líquenes y musgos de todo el planeta. Un nuevo libro y un documental en DVD invitan a descubrirla.

Investigación analizó a más de 1.300 menores:

Estudio demuestra que los niños chilenos son tan felices como los suecos

Aunque hay una gran brecha entre los adultos de ambos países, hasta los 14 años, quienes viven en Chile dicen sentirse incluso más satisfechos con su colegio y hermanos.

Sin que se vean distorsiones:

Científicos logran hacer invisible un objeto

Investigación del MIT:

Implante auditivo usa la energía del cuerpo

El Mercurio newspaper article highlighting the innovative practice of Ecotourism with a Hand Lens at Omora Park to appreciate the high diversity of bryophytes and their multiple ecological, aesthetic, economic, and ethical values.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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Subantarctic Magellanic Ecoregion

Timeline: Microcosm

2002

In 2002, the region's name changed to "subantarctic Magellanic ecoregion." This term has the advantage of clearly distinguishing it from three other geographically or climatically related regions. First, it distinguishes this rainy mountainous region from the dry, flat steppes of Patagonia. Second, being dominated by forests, the subantarctic Magellanic ecoregion is also distinct from all other subantarctic island regions, which completely lack other woody plants. Third, the forests of the subantarctic Magellanic ecoregion are dominated by evergreen broadleaf trees, which distinguishes them from the boreal or subpolar region in the Northern Hemisphere dominated by conifers and deciduous broadleaf trees.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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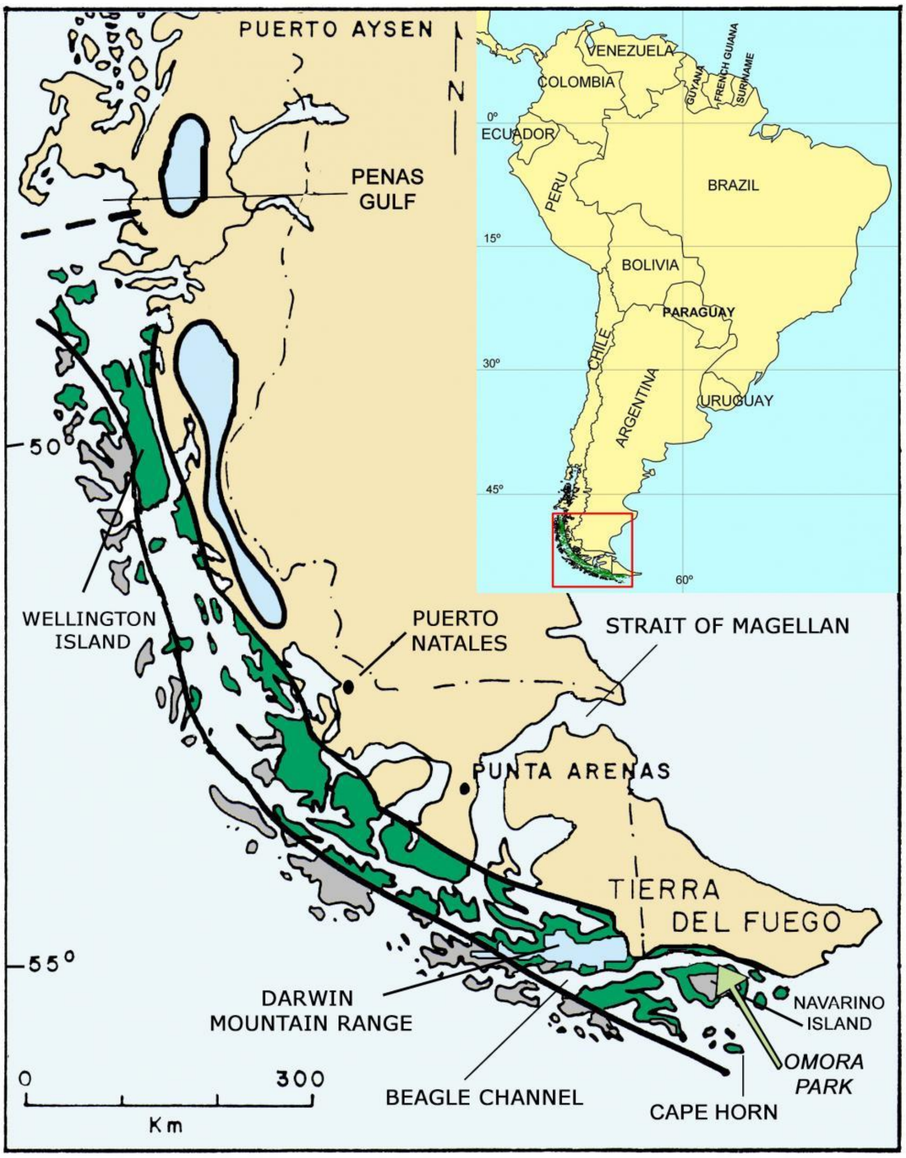

The subantarctic Magellanic ecoregion, showing the full extent of evergreen rainforests (green) and Magellanic moorland (gray) from Cape Horn to Penas Gulf in Chile. Located on Navarino Island, south of Tierra del Fuego, Omora Ethnobotanical Park launched a bryoflora conservation program with international collaboration in 2000. Omora Park serves as a long-term ecological research site and the research, education, and conservation center for the Cape Horn Biosphere Reserve (CHBR). Maps published in this document that refer to or relate to the limits and borders of Chile do not commit the State of Chile in any way, in accordance with Article 2, letter g of DFL No. 83 of 1979, of the Chilean Ministry of Foreign Affairs.

Ricardo Rozzi et al. “From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile’s Biocultural Laboratories.” Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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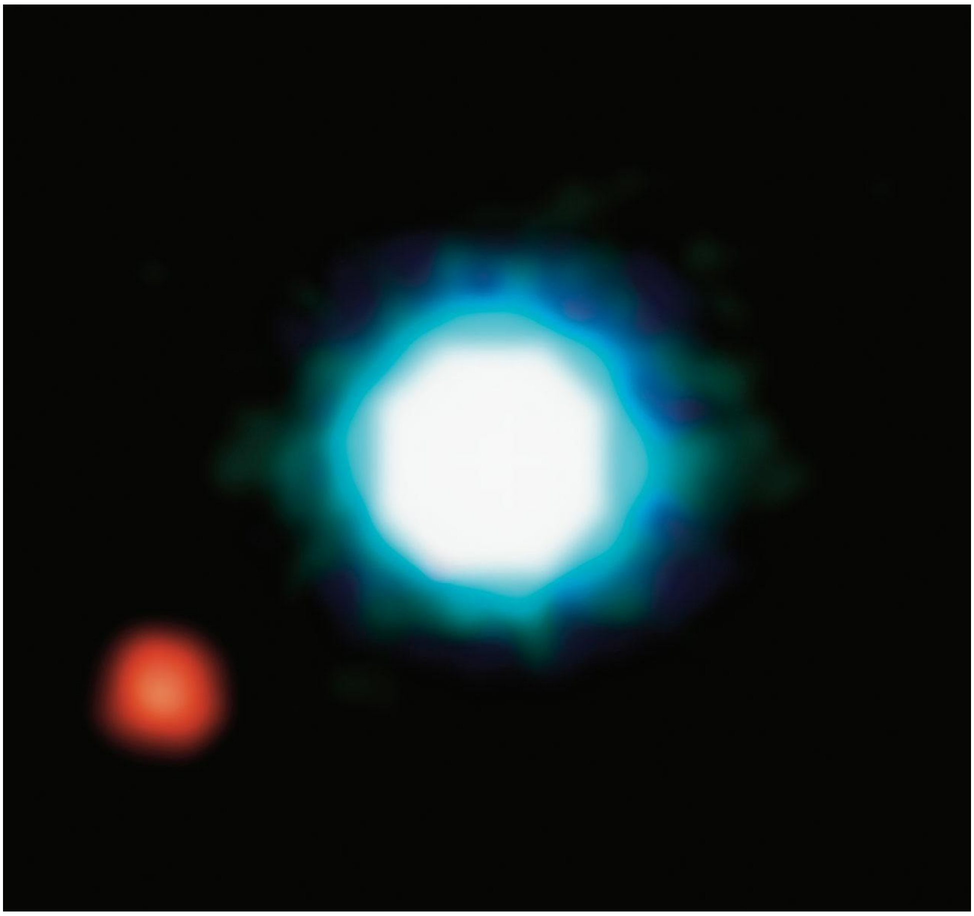
First Image of an Exoplanet

Timeline: Macrocosm

10 September 2004

In 2004, the VLT broke new scientific ground by obtaining the first-ever image of a planet outside the solar system. The planet, displayed as a red shape in the image, is more than one hundred times fainter than its host star 2M1207. Its near-infrared spectrum was obtained with great efforts by the NACO at the VLT, at the technical limit of the powerful facility.



This image shows an exoplanet (the red spot in the lower left) orbiting the brown dwarf 2M1207 (center).

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/26a_big-vlt/

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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UNESCO Recognition and Creation of the Cape Horn Biosphere Reserve

Timeline: Microcosm

2005

The long-term botanical fieldwork in the Cape Horn region disclosed a floristic anomaly: non-vascular plants had a greater diversity than vascular plant species. Moreover, the subantarctic Magellanic ecoregion hosts more than 5 percent of the world's species of non-vascular plants in less than 0.01 percent of the world's land surface. This discovery provided the central argument to create the UNESCO Cape Horn Biosphere Reserve in 2005. For the first time, a biosphere reserve was designated based on the diversity of mosses. These tiny organisms had rarely been perceived and valued in the international conservation community.

The Reserve Proposal was approved by UNESCO in June 2005. On the left, the back cover includes the UNESCO certificate and the map of this biosphere reserve that comprises 5 million hectares of terrestrial and marine ecosystems, and is the largest of southern South America (i.e., Uruguay, Argentina, Chile). On the right, a lichen in the center shows the essential role that lichens and bryophytes play in the ecosystems of Cape Horn. In the lower right corner, Julia Gonzalez, handcrafter of the Yahgan Indigenous community, holds a handcrafted bark canoe in her hands to illustrate the intimate links between these ecosystems and her ancestral culture.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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First Light of APEX

Timeline: Macrocosm

14 July 2005

The submillimeter Atacama Pathfinder Experiment (APEX) had its first light in 2005 on the Chajnantor plain of the Chilean Andes. The 12-meter dish is the successor to the Swedish–ESO Submillimeter Telescope (SEST), and works to break new ground for upcoming submillimeter telescopes. It was developed by a collaboration between the Max Planck Institute for Radio Astronomy (MPIfR), the Swedish Onsala Space Observatory (OSO), and ESO.

The Atacama Pathfinder Experiment (APEX) antenna on the Chajnantor plain of the Chilean Andes, 5,000 meters above sea level. Unknown photographer, n.d.

Courtesy of Iztok Bončina/ESO.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/ib-alma14/

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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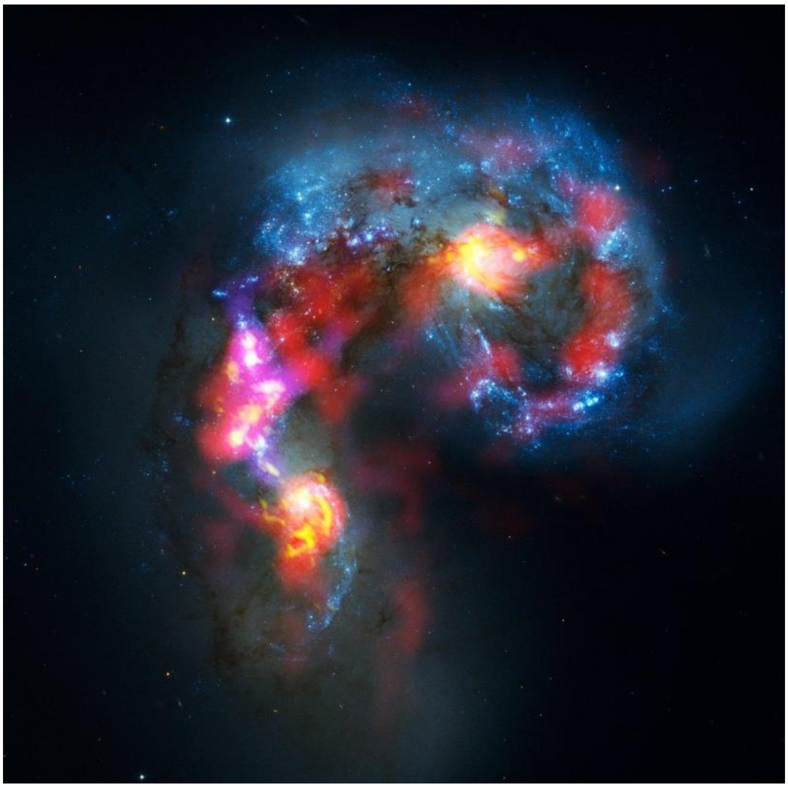
ALMA Sees First Light

Timeline: Macrocosm

17 September 2009

In 1995, site testing for the Atacama Large Millimeter/submillimeter Array (ALMA) started. In 2003, the Republic of Chile granted free concession of the land on Chajnantor in the Atacama Desert to host the array. On 17 September 2009, the first ALMA antenna arrived at the 5,000-meter altitude Chajnantor site. The first image from ALMA was published only two years later, showing a never-before-seen view of the Antennae Galaxies. ESO is a partner in ALMA, together with the National Radio Astronomy Observatory (NRAO) and the National Astronomical Observatory of Japan (NAO).



This image shows the Antennae Galaxies located about 70 million light years away. It combines ALMA observations with visible-light observations from the NASA/ESA Hubble Space Telescope.

Courtesy of ALMA (ESO/NAOJ/NRAO). Visible light image: the NASA/ESA Hubble Space Telescope. Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/eso1137a/

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First Light for VISTA

Timeline: Macrocosm

11 December 2009

In 2009, the Pioneering Visible and Infrared Survey Telescope for Astronomy (VISTA) had its first light. VISTA is situated at Paranal, close to the VLT, and with its four-meter mirror it is one of the world's largest telescopes dedicated to mapping the sky. On top of that, it is an expert at capturing stunning images of the universe, like the first image ever to be released publicly from VISTA (a view of the Flame Nebula).

This image displays the spectacular star-forming region known as the Flame Nebula.

Courtesy of ESO/J. Emerson/VISTA.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/eso0949a/

Infrastructure of Scientific Laboratories

Timeline: Microcosm

2010

The Omora Park Field Station and the Wankara Freshwater Studies Laboratory were created through a partnership between the University of Magallanes in Chile and the University of North Texas in the United States. This facility in Puerto Williams, capital of the Chilean Antarctic Province, provided the first major infrastructural platform for long-term research, education, and science-based conservation in the Cape Horn Biosphere Reserve (CHBR).

The Róbalo River watershed illustrates the "cleanest freshwaters of the world" that are protected by Omora Park. Photograph by Paola Vezzani, n.d.

Construction of the ELT Starts

Timeline: Macrocosm

19 April 2014

After being chosen as the site to host the world's biggest eye on the sky, the Extremely Large Telescope (ELT), in 2010, construction started taking place at Cerro Armazones in 2014, only 20 kilometers from Paranal Observatory.

This photograph, taken from Cerro Paranal about 20 kilometers away, shows how parts of the 3,000 meter high peak of Cerro Armazones have been blasted away to prepare the summit for the construction of ESO's European Extremely Large Telescope (E-ELT). Unknown photographer, n.d.

Courtesy of ESO/I. Saviane.
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/eso1419d/

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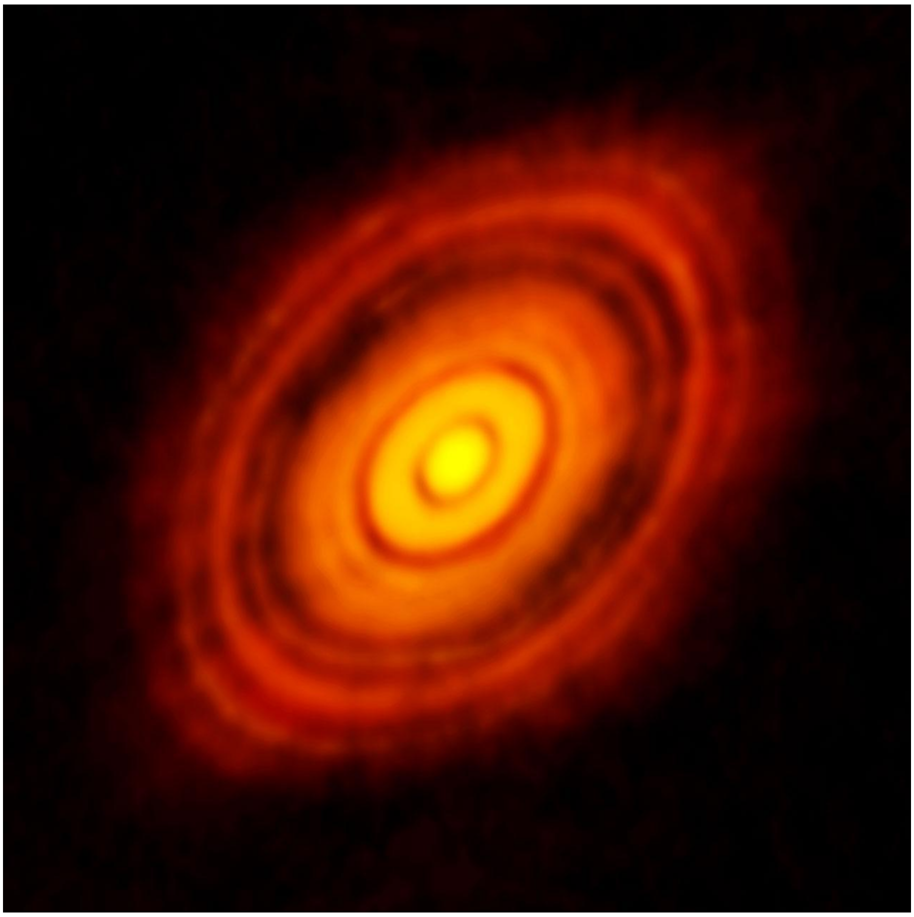
ALMA Images Planetary Nursery

Timeline: Macrocosm

6 November 2014

Thanks to ALMA, extraordinary, never-seen-before details of a planet-forming disc around a young star were captured in images. These images would prove to be an enormous step forward in observations of these discs and in increasing our understanding of how planets form.



This image taken by ALMA shows the protoplanetary disc surrounding the young star HL Tauri.

Courtesy of the ALMA (ESO/NAOJ/NRAO).
Click here to view source.

Websites linked in image captions:

https://www.eso.org/public/images/eso1436a/

The Southernmost Scientific Congress in History

Timeline: Microcosm

2015

The Omora Park research team in collaboration with the International Association of Bryologists organized the 2015 World Congress of Bryology that was held at Omora Park and the Donald McIntyre High School in Puerto Williams. This conference was the southernmost scientific congress in history.

Participants in the International Association of Bryologists World Congress in January 2015 at the entrance of Omora Park. Participants included not only Chilean and international scientists, but also members of indigenous communities, government authorities, teachers, students, artists, philosophers, and former president of Chile, Michelle Bachelet. Unknown photographer, n.d.

Creation of the Cape Horn Long-Term Ecological Research Network (LTER-Cape Horn)

Timeline: Microcosm

2016

In 2008, the Omora Park research team cofounded the Chilean Long-Term Socio-Ecological Research Network (LTSER), and in 2016 expanded this network with the addition of the Cape Horn Long-Term Ecological Research Network (LTER-Cape Horn). The latter includes four sites, which from south to north are:

(1) Gonzalo Island (56°31' south, 68°43' west), at the southern end of the Diego Ramírez Archipelago, with subantarctic vegetation dominated by grasses and cryptogams, devoid of woody species.

(2) Horn Island (55°58' south, 67°13' west), at the southern end of the Cape Horn Archipelago, hosting the southernmost forest ecosystems on the planet, which are dominated by the evergreen beech (*Nothofagus betuloides*).

(3) Omora Park (54°57' south, 67°40' west), Navarino Island, an ideal site for studies on climate change and its impact on biota and subantarctic ecosystems, since it protects a watershed that includes a representative mosaic of characteristic habitats of the Cape Horn Biosphere Reserve (CHBR) in an altitudinal gradient with a thermal decrease analogous to that which occurs with increases in latitude.

(4) Caleta 2 de Mayo Site (54°52' south, 68°41' west), Yendegaia Bay, in an ecotonal zone between evergreen and deciduous forests (product of the local climate gradient), at a site that will be central to future connectivity between continental Chile, Tierra del Fuego, Navarino Island, and the CHBR.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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Authorities and researchers of Omora Park, administrated by the University of Magallanes and the Omora Foundation, including representatives from the Pontifical Catholic University of Chile, the University of Chile, and the University of North Texas, USA. Omora Park researchers led the proposal for creating the Cape Horn Long-Term Ecological Research Network (LTER-Cape Horn). From left to right: Dr. José Maripani (rector, University of Magallanes), Dr. Richard Nader (former vice president, University of North Texas), Dr. Ignacio Sánchez (rector, Pontifical Catholic University of Chile), David Holdeman (former dean of college of arts and sciences), Dr. Patricio Arce (director of the Laboratory of Plant Physiology, Pontificial Catholic University of Chile), Ricardo Rozzi (director, Cape Horn International Center, University of Magallanes/North Texas University). Unknown photographer, October 2015.

Ricardo Rozzi et al. “From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile’s Biocultural Laboratories.” Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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Cape Horn Biosphere Reserve is Recognized as One of the 2016 Top 100 Sustainable Destinations

Timeline: Microcosm

2016

The Cape Horn Biosphere Reserve (CHBR) was recognized as one of the 2016 Top 100 Sustainable Destinations in the world by Green Destinations, and was awarded a certificate at the Green Destinations Day Gala in the Slovenian capital, Ljubljana. The award recognized the CHBR's celebration of nature, biodiversity, and cultural values within the destination.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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EL MERCURIO

Vida • Ciencia • Tecnología

SANTIAGO DE CHILE, MARTES 27 DE SEPTIEMBRE DE 2016

El extremo austral está en la lista "Top 100 Destinos Sustentables 2016":

Cabo de Hornos es elegido uno de los destinos ecológicos del planeta

Factores como su biodiversidad y la oferta de un turismo responsable con el medio ambiente caracterizan a esta zona que abarca 5 millones de hectáreas.

Ecoturismo con lupa

Superan el centenar:

Aumentan casos de zika autóctono en EE.UU.

Experimento realizado en el parque de diversiones Disney en Orlando:

Una vuelta en montaña rusa puede eliminar pequeños cálculos renales

Usando un modelo de riñón, dos médicos comprobaron que las anécdotas de sus pacientes tenían fundamento.

De 10 a 30 segundos:

Snapchat crea lentes que graban minivideos

El Mercurio newspaper article communicating that the Cape Horn Biosphere Reserve has been identified as one of the top 100 green destinations for sustainable tourism.

Forging a Sustainable Future

Timeline: Macrocosm

23 September 2016

ESO is fully committed to fighting climate change by reducing the environmental impact of its activities. As part of this, La Silla is operated on green energy from a solar power plant. As of 2022, Paranal Observatory too is powered by solar energy, thanks to a groundbreaking facility that will bring clean energy to the ELT at Cerro Armazones in the future. Energy not used by the observatories is directed into the Chilean power grid.

This image illustrates the photovoltaic systems that provide daytime electricity to ESO's Paranal Observatory and ESO's ELT construction site on Cerro Armazones. Unknown photographer, n.d.

Courtesy of ESO.
Click here to view source.

Websites linked in image captions:

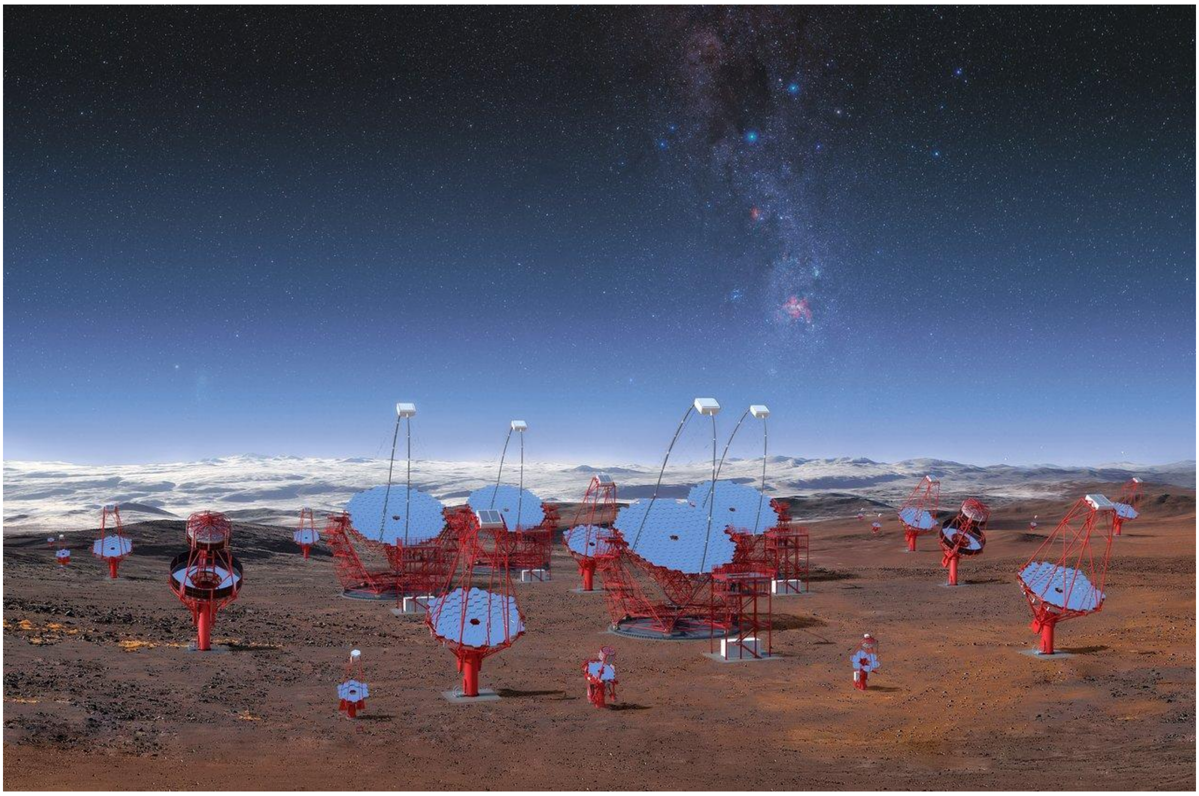
https://www.eso.org/public/images/ann22010b/

Paranal to Host the Cherenkov Telescope Array-South

Timeline: Macrocosm

20 December 2018

The Chilean government and ESO signed an agreement enabling ESO to host the Cherenkov Telescope Array-South (CTA-S) at Paranal Observatory. The CTA-S will be the world's most ambitious gamma-ray observatory to access not only Chile's pristine observing conditions, but also ESO's state-of-the-art infrastructure, expertise, and facilities. The CTA-S will be key for studying extreme objects in the universe such as supermassive black holes, supernovae, and maybe even remnants of the Big Bang.



This artist rendering illustrates the enormous scale of the CTA telescopes and the array itself.

Courtesy of CTA/M-A. Besel/IAC (G.P. Diaz)/ESO.
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Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
Chapter: Timelines
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Creation of the Diego Ramírez Islands–Drake Passage Marine Park

Timeline: Microcosm

2019

Between 2015 and 2019, the Omora Park scientific team prepared the technical report and, together with the Ministry of the Environment, the Ministry of National Assets, the Undersecretariat of Fisheries and Aquaculture, and the National Forest Corporation, led the process of creating the Diego Ramírez Islands–Drake Passage Marine Park. Its creation was officially announced in 2019, giving protection to the southernmost islands of the American continent and 144,390.6 square kilometers of the marine ecosystems of the Drake Sea. These terrestrial and marine ecosystems are unique worldwide.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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EL MERCURIO

Vida • Ciencia • Tecnología

vct@mercurio.cl @VCT_ElMercurio SANTIAGO DE CHILE, JUEVES 25 DE ENERO DE 2018

Aprobado el lunes en Consejo de Ministros y abarca una superficie de 140 mil km²:

La ciencia tras el proyecto que dio vida al Parque Marino Diego Ramírez-Paso Drake

Dieciocho años de investigación y un proceso continuo de diálogo entre la comunidad científica y la industria pesquera permitieron delimitar un área donde se pretenden fortalecer la biodiversidad y la sustentabilidad económica.

JANINA MARCANO FERMIN

"Con esto, Chile se transforma en un centinela del cambio climático". Así describe el investigador Ricardo Rozzi la creación del Parque Marino Diego Ramírez-Paso Drake, que se aprobó el pasado lunes en el Consejo de Ministros y que abarca una superficie de 140 mil km².

Rozzi es director del Programa de Conservación Biocultural Subantártica de la Universidad de Magallanes y uno de los impulsores de este parque, que resguardará el archipiélago Diego Ramírez y los montes submarinos del paso Drake.

La aprobación se logró después de 18 años de investigación científica. Según Rozzi, esto fue uno de los pilares fundamentales del éxito del proyecto, pues se logró la identificación de lugares únicos de conservación, lo que permitirá estudiar, entre otras cosas, el impacto del cambio climático en las especies que allí se encuentran.

"Pudimos lograr varias escalas donde nos preocupamos de los ecosistemas marinos, pero también de todas las algas, los pingüinos y el ensamble de aves en general", dice.

Sebastián Rosenfeld, investigador de la Universidad de Magallanes, estuvo a cargo de levantar información en los últimos cuatro años. "La investigación arrojó muchas sorpresas, como que el archipiélago Ramírez no tiene especies exóticas ni marinas ni terrestres, y eso lo hace un lugar único para estudiar".

El proceso incluyó al menos cinco expediciones grandes en colaboración con la Armada de Chile.

"Ser tan precisos en la investigación fue lo que nos permitió compatibilizar el área protegida con la zona de pesca para impulsar un modelo que supera el conflicto histórico entre desarrollo y conservación", dice Rozzi. Precisamente, esta compatibilidad ha sido uno de los puntos más destacados desde que se presentó la propuesta de área marina protegida.

Al norte, tiene una delimitación con una zona determinada para la pesca industrial.

De la zona del archipiélago, el parque marino solo tomó 5,1% del área de extracción de merluza y 8,9% de la de bacalao.

Para proyectos futuros, Rozzi destaca la importancia de los procesos participativos, donde se realiza una transferencia de la ciencia, pero también se está dispuesto a escuchar.

"Fue una especie de junta médica. Participamos en los comités de trabajo con los sectores de pesca. Eso generó un proceso donde fuimos adaptando las medidas y llegamos al mapa actual", asevera.

Un tercer pilar clave del proyecto tiene que ver con el compromiso de las organizaciones involucradas de realizar estudios a largo plazo que les demuestren a otras generaciones que el trabajo conservacionista funciona.

"En dos semanas vamos a adjudicar la construcción del Centro Subantártico Cabo de Hornos, lo que nos permitirá hacer ciencia de alto nivel", agrega.

Rosenfeld asegura que la creación del parque posibilitará hacer estudios más exactos para evaluar cómo los cambios afectan a las comunidades biológicas, lo que incluye a las de valor comercial. "La idea es recibir apoyo para poder hacer investigación que responda a la esencia de la mirada compartida que tiene este proyecto", puntualizó.

Conservación y pesca

La propuesta para la creación del parque marino tuvo un enfoque de protección de la biodiversidad y la sustentabilidad económica.

Fuente Universidad de Magallanes — EL MERCURIO

El pingüino de penacho amarillo es una especie vulnerable que habita la zona del nuevo parque.

Los desafíos para la protección

Ruth Alarcón, jefa del departamento de Gestión Ambiental de Sernapesca, advierte que la creación de este nuevo parque supone un desafío particular al tratarse de zonas de difícil acceso, como es el caso del parque Cabo de Hornos. " No solo en términos de un mayor presupuesto, sino también una dotación acorde, la incorporación activa de otros actores interesados, como la comunidad científica y las ONG, y la adopción de nuevas tecnologías que complementen y refuercen la labor que se realiza hasta ahora, en particular tratándose de zonas de tan difícil acceso", comentó.

La principal zona de nidificación del albatros de cabeza gris, especie vulnerable, es el Archipiélago Diego Ramírez.

La meseta isla Gonzalo (en la imagen) es parte del archipiélago Diego Ramírez. En ella se realizan principalmente estudios de insectos.

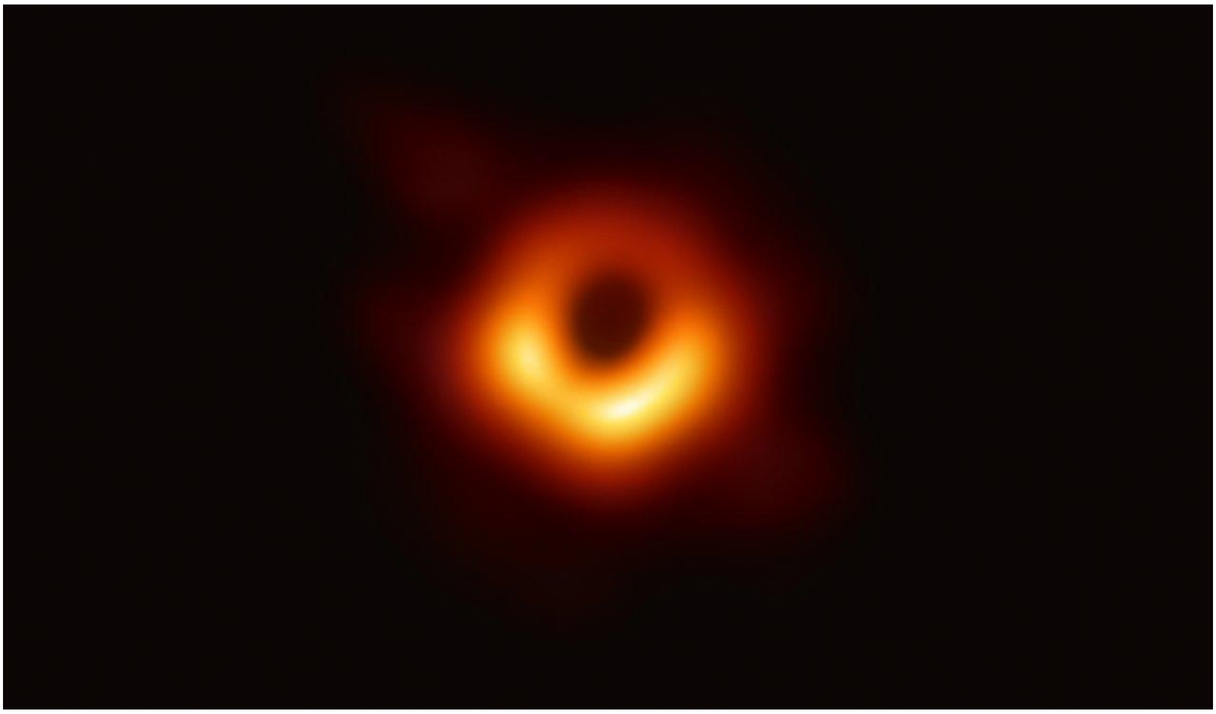
El Mercurio newspaper article communicating the creation of the Diego Ramírez Islands–Drake Passage Marine Park in January 2019.

First Image of a Black Hole

Timeline: Macrocosm

20 April 2019

The Event Horizon Telescope (EHT), a planet-scale array of eight ground-based radio telescopes forged through international collaboration, where ESO participates through ALMA and APEX, imaged a black hole for the first time in 2019: the supermassive black hole at the centre of the Messier 87 galaxy.



This is the first image of a black hole.

Courtesy of the EHT Collaboration.
Click here to view source.

Websites linked in image captions:

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Total Solar Eclipse at La Silla

Timeline: Macrocosm

2 July 2019

On 2 July 2019 a total solar eclipse passed over La Silla Observatory. The eclipse lasted roughly two and a half hours, with almost two minutes of totality, and was visible across a narrow band of Chile and Argentina. To celebrate this rare event, in the same year as La Silla celebrated its 50th anniversary, ESO invited one thousand people, including dignitaries, school children, the media, researchers, and the general public, to come to the observatory to watch the eclipse from this unique location.

Photograph of the total solar eclipse at La Silla Observatory on 2 July 2019.

Courtesy of ESO/R. Lucchesi.
Click here to view source.

Websites linked in image captions:

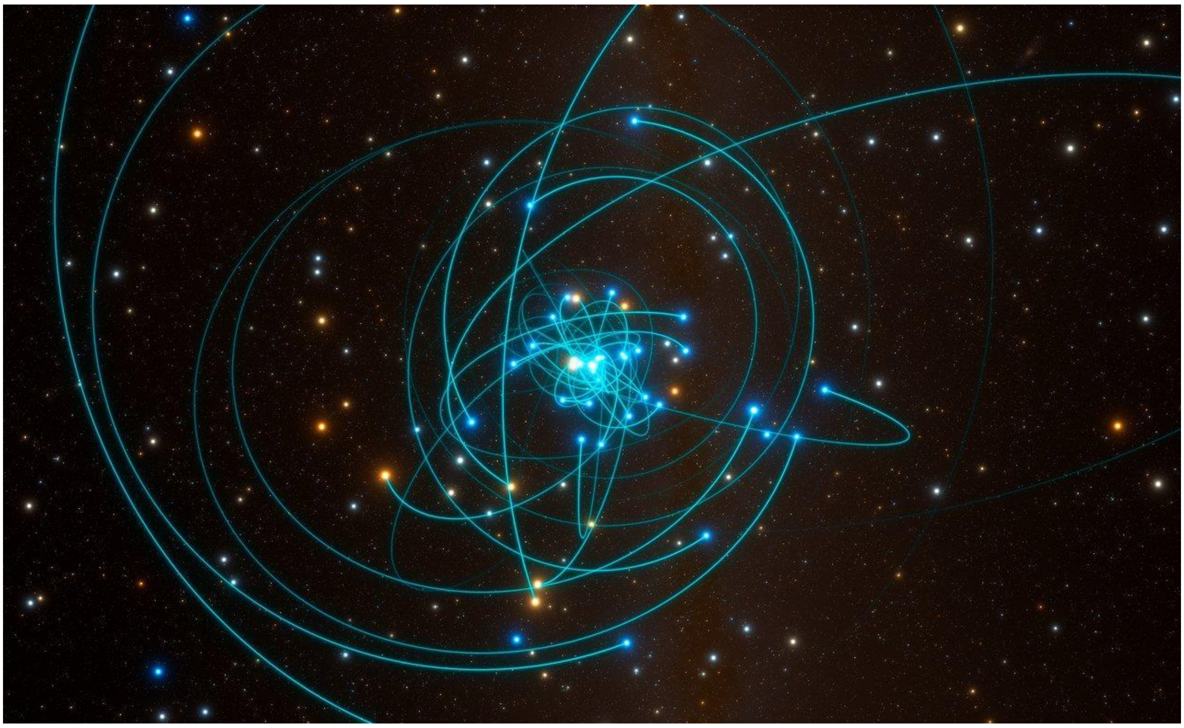
https://www.eso.org/public/images/eso1912a/

Award-Winning Black Hole Discovery

Timeline: Macrocosm

6 October 2020

After 30 years of observations, using a fleet of instruments on various ESO telescopes, Reinhard Genzel, together with Andrea Ghez (who used the US W. M. Keck Observatory telescopes), delivered the best empirical evidence of the existence of a supermassive black hole at the center of the Earth's galaxy. For this, they were awarded the Nobel Prize in Physics (2020). Genzel and his team were heavily involved in developing the GRAVITY instrument on the VLT Interferometer, which was key for many of the discoveries they have made about the supermassive black hole, Sagittarius A*, and they are now involved in the development of instruments that will be installed on the ELT, which will enable them to probe the environment even closer to the black hole.



In this image, an artist illustration shows the tracks of the stars as they orbit the supermassive black hole at the heart of the Milky Way.

Courtesy of ESO/L. Calçada/spaceengine.org.
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Websites linked in image captions:

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Creation of the Cape Horn International Center (CHIC)

Timeline: Microcosm

2021

The Cape Horn International Center (CHIC, Basal Financing Program for Centers of Scientific and Technological Excellence, ANID, CTCI Ministry) integrates the natural and social sciences, the humanities, education, and environmental ethics to appreciate and care for biodiversity from the scale of small organisms to the planetary scale.

The three main research areas of CHIC are:

1. sentinels of climate change—responses of subantarctic and high Andean biodiversity to climate change;

2. sentinels of biocultural homogeneization—responses of biocultural diversity to global social-enviromental change;

3. biocultural conservation at multiple scales.

CHIC's headquarters will be based at the new facility of the Cape Horn Sub-Antarctic Center (a GORE-FNDR project), the Long-Term Ecological Research Network site (LTER-Cape Horn). CHIC will carry out most of its outreach, education, and on-site research activities at the new facility, representing a US$20 million investment project by the regional government of Magallanes, Chile. Built on a 2.2-hectare site in the city of Puerto Williams, the building is 2,581 square meters large and has LEED environmental certification. It will host the world's southernmost university headquarters, and it is organized in three modules: (1) Technical Education, (2) Sustainable Tourism and Biocultural Conservation, and (3) Transdisciplinary Research.

EL MAGALLANES

Ciencias

domingo 26 de septiembre de 2021 | 1

Imagen aérea del Centro Subantártico Cabo de Hornos.

» La Universidad de Magallanes se adjudicó un fondo basal por $1.400 millones anuales para dicho centro. En su reciente visita a Punta Arenas, el ministro de Ciencia, Andrés Couve, valoró la iniciativa, afirmando que ayuda a consolidar a la región como un polo científico-tecnológico y también logístico para temas antárticos y subantárticos

Centro Cabo de Hornos logró financiamiento de la Anid por 10 años

"Magallanes será centinela del cambio climático y de desarrollo sostenible para el mundo"

El ministro de Ciencia, Tecnología, Conocimiento e Innovación, Andrés Couve Correa, trajo excelentes noticias para Magallanes: la adjudicación de un fondo basal por $1.400 millones anuales para el "Cape Horn International Center for Global Change Studies and Biocultural Conservation" (CHIC), proyecto científico de la Universidad de Magallanes (Umag) que está emplazado en Puerto Williams.

"Esto nos ayuda a consolidar a Magallanes como un polo científico-tecnológico y también logístico para temas antárticos y subantárticos y, de igual forma, a posicionar, internacionalmente, un laboratorio natural único en Chile que nos ofrece grandes oportunidades de investigación, lo que genera, sin duda, externalidades hacia la economía, hacia la sociedad, hacia la educación en una región con tanto potencial como ésta", sostuvo Couve.

El CHIC se propone ser un nodo articulador de conocimiento al sur de Chile, para lo cual ha establecido una alianza con diversas universidades y centros de investigación del país. Así, desarrollará trabajos e investigaciones en torno al impacto del cambio climá-

El jueves pasado, el ministro Couve y el equipo directivo universitario encabezado por el rector Juan Oyarzo Pérez, se reunieron en dependencias del Cadi-Umag y se conectaron vía telemática con el director del proyecto, el investigador y profesor Ricardo Rozzi Marín.

Sigue en la P2

Ciencia y educación en red y para el mundo

En este proyecto, se trabajará de la mano de un consorcio de instituciones chilenas, el que está conformado por la Pontificia Universidad Católica de Chile (Puc), la Universidad de Chile, la Universidad Central, el Centro de Investigación en Ecosistemas de la Patagonia (Ciep), la Universidad Católica de Temuco, la Universidad de Talca y la Universidad de Los Lagos. A ellos, se suma, además, la Universidad de North Texas (Estados Unidos), como entidad socia a nivel internacional.

Rozzi indicó que los y las investigadores participantes buscarán posicionar a nuestro país y la zona austral como un territorio centinela del cambio climático y, a su vez, de desarrollo sostenible para el mundo. En ese contexto, puntualizó que sus pilares se cimentarán no sólo en lo científico, sino también en lo educativo, donde esperan poder levantar programas desde una aproximación biocultural.

"Enfatizamos la importancia que la educación esté centrada en la riqueza, en el patrimonio biológico y cultural y ahí estamos trabajando junto con otras regiones del país como La Araucanía y también con países como México, (Galápagos) Ecuador, Brasil, etc. para ver qué programas educativos podemos brindar desde Magallanes hasta el norte de Latinoamérica", explicó.

2 | Ciencias

EL MAGALLANES

Viene de la P1

tico sobre la biodiversidad subantártica y sus ecosistemas; a procesos y metodologías de educación, conservación biocultural, ética ambiental y políticas públicas que fomenten la sustentabilidad social, económica y ambiental; y al aprovechamiento de las ventajas comparativas del entorno territorial y los recursos endógenos con el fin de mejorar el bienestar y la calidad de vida de su población.

Los recursos adjudicados provienen del Cuarto Concurso Nacional de Financiamiento Basal para Centros Científicos y Tecnológicos de Excelencia 2021 de la Agencia Nacional de Investigación y Desarrollo (Anid), iniciativa que permitirá concretar, al alero del Centro Subantártico Cabo de Hornos en Puerto Williams, un espacio multidisciplinario y colaborativo en torno a la investigación, la educación, la conservación y la economía sostenible desde el punto más austral del planeta.

Durante su reciente visita a Punta Arenas, Couve y el equipo directivo universitario encabezado por el rector Juan Oyarzo Pérez, se reunieron en dependencias del Cadi-Umag y se conectaron vía telemática con el director del proyecto, el investigador y profesor Ricardo Rozzi Marín. Allí repasaron los alcances de lo que será este inédito desarrollo científico en Magallanes, el que recibirá, a contar de su implementación, en enero de 2022, un total de $1.400 millones anuales por un periodo de 10 años, cinco fijos y cinco prorrogables.

"Nunca nos habíamos adjudicado un proyecto de esta envergadura y, como decía el ministro, es una señal que quiere dar también a los territorios, sobre todo a las universidades regionales, porque fuimos una de las pocas que nos adjudicamos un fondo basal. Aquí serán 10 años de investigación y muchos los recursos que se entregan, con una combinación, además, de muchos investigadores e investigadoras, así que estamos muy contentos de esta visita y del apoyo que tanto el Ministerio de Ciencia como la seremía de la macrozona austral nos han entregado", manifestó el rector Oyarzo.

» Laboratorio natural es un espacio geográfico delimitado que posee características únicas que son casi irreproducibles o que se preservan prácticamente en su estado original. Allí se puede observar y probar hipótesis sobre procesos naturales de interés científico

» La zona antártica y subantártica es uno de los laboratorios naturales más emblemáticos del mundo, ya que posee diversas características naturales, ambientales y geográficas que la hacen única, siendo altísimo su valor científico.

» El territorio antártico y subantártico es considerado un espacio propicio para el estudio del fenómeno del cambio global, siendo importante el encadenamiento de los saberes científicos y la transmisión de conocimiento desde y entre el mundo de la investigación, los sectores productivos, la sociedad civil, el gobierno y los gestores del territorio

Article in *El Magallanes* communicating that the Cape Horn International Center (CHIC) was created in November 2021. CHIC is funded by the Basal Financing Program for Centers of Scientific and Technological Excellence (ANID) of the Chilean Ministry of Sciences. It is a transdisciplinary initiative that integrates natural and social sciences, humanities, education, and environmental philosophy to appreciate and care for biodiversity from the scale of small organisms to the planetary scale. CHIC is housed in a building of the Cape Horn Center in Puerto Williams with three modules, one dedicated to technical and high education, another to tourism of special interests and biocultural conservation, and a third to biocultural research.

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CHIC’s and ESO’s multiple-scale exploration.
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Tetraplodon, Cape Horn Biosphere Reserve.
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Cladonia and hand lens.

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Alcances botánicos: libros ("Botanical scope: books") by Rodrigo Arteaga.

Ricardo Rozzi et al. "From Hand Lenses to Telescopes: Exploring the Microcosm and Macrocosm in Chile's Biocultural Laboratories." Environment & Society Portal, *Virtual Exhibitions* 2023, no. 1. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/9506.
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Illustration by Ennead Architects, 2015.

Cape Horn Center design.

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