

Charting a path for microbial conservation in the IUCN: report on “Conservation in a Microbial World” meeting in San Diego, CA, May 2025

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Abstract

In May 2025, the “Conservation in a Microbial World” conference was hosted at UC San Diego’s Scripps Institution of Oceanography to address the lack of microbial representation in international conservation frameworks (i.e. International Union for Conservation of Nature—IUCN). Organized by Drs. Redford, Gilbert, Friedman, and Rodríguez, the meeting explored the importance of the microbial world in conservation and what can be done to include microbes in global conservation. The meeting gathered together experts in fungi, bacteria, and viruses with backgrounds in climate science, genomics, terrestrial and aquatic ecosystems, and human health, spanning research, industry, conservation, and policy. Key themes included: how to communicate the importance of microbes, how to conserve microbes themselves, and how microbes could be integrated into existing conservation. The primary outcome was the launch of the IUCN Species Survival Commission—Microbial Conservation Specialist Group. This initiative marks a pivotal step toward incorporating microbial life into global biodiversity conservation policy and practice.

Sustainability Statement

The meeting focused on enhancing Global Partnerships (UN SDG1: Partnerships for the goals) to address microbial conservation. Global partnerships are fundamentally necessary to advance microbial conservation efforts. The meeting also addressed topics related to One Health (UN SDG3: Good health and wellbeing), Ocean Sustainability (UN SDG14: Life below water), Healthy Land (UN SDG15: Life on land), and Climate Action (UN SDG13). Conservation of microbes and critical microbial functions will help to maintain and improve human, animal, land, and ocean health.

Keywords: Bacteria,; Climate; Ecosystem functioning; Environmental microbiology; Archaea

Introduction

The International Union for Conservation of Nature (IUCN) was formed in 1948 and is most recognized for producing the IUCN Red List of Threatened Species. Every four years, IUCN Members convene at the World Conservation Congress, a gathering of conservation professionals and experts from around the world who vote on pressing issues and make decisions on behalf of the Union. IUCN aims to maximize the impact of conservation practice on the ground and in the water, as well as to influence the creation of conservation policies across the globe. It laid the groundwork for the Convention on International Trade in Endangered Species, the Convention on Biological Diversity, the establishment of protected areas of the deep sea, the Global Strategy on Plant Conservation, the United Nations list of National Parks and Equivalent Reserves, to name a few (IUCN 2018). However, the Union has yet to address microscopic life. IUCN has only recently included fungi (IUCN 2012), rarely covers viruses or single-cell eukaryotes, and has never included two entire domains of life: the bacteria and archaea.

To address this gap, we recently held a three-day conference, “Conservation in a Microbial World,” in May of 2025 to develop a proposal to IUCN to include bacteria, archaea, viruses, single-cell eukaryotes, and microscopic fungi in the conservation agenda. The conference was organized by Drs. Kent Redford, Jack Gilbert, Bob Friedman, and Jon Paul Rodríguez. We wanted to explore the potential of conservation of microbial species and ecosystems, and the potential of microbes to augment existing conservation efforts for macrobial species (plants, animals, etc.; Fig. 1). Experts from around the globe gathered in San Diego, California, at the UC San Diego Scripps Institution of Oceanography to discuss whether it is important and feasible to conserve microbes, and if so, how this should be reflected in the work of IUCN. The objectives posed to the attendees were as follows:

1. Build the capacity and interest of the global conservation community in the microbial world through the IUCN Species Survival Commission (SSC), by es-

tablishing a Microbial Conservation Specialist Group (MCSG). Through the work of such a group the ~1 500 Member institutions of IUCN and >10 000 expert members of SSC would learn more about the importance of the microbial world to conservation, what work should be done, and why.

2. Increase awareness of how specialists in the microbial world can extend their work addressing pressing conservation problems through contacts made at the meeting and subsequent publications.
3. Generate key examples of how microbe-aware conservation strategies would significantly improve existing conservation and restoration action globally.

The meeting was formatted to allow open discussion, intermixed with brief presentations from experts in microbial ecology and conservation. The meeting was initiated with a welcome by the organizing committee and a presentation by Dr. Jack Gilbert on how far we have come from the first discovery of microbes to now, highlighting the importance of microbial diversity across systems and the power of microbial technologies as we face global challenges. Additional speakers highlighted specific examples of microbial ecosystems under threat, and examples of how microbes could be brought into the conservation conversation. Further presentations highlighted key stressors to microbes, which are naturally very similar to those faced by eukaryotes, and include i.e. climate change, cryosphere melt, pollution, freshwater use, and land use change and development. Although the scope of these presentations ranged from regional to global in nature, participants noted the lack of sufficient representation from the Global South and carried this consideration throughout meeting discussions. The presentations were intermingled with breakout sessions where participants considered issues such as “What do we mean by conservation in a microbial world?” and moved into action, with “Defining Key Activities.” Another critical phase of the meeting was sharing insights into the programs, structure, and governance of IUCN, with discussions on the concept of conservation, examples

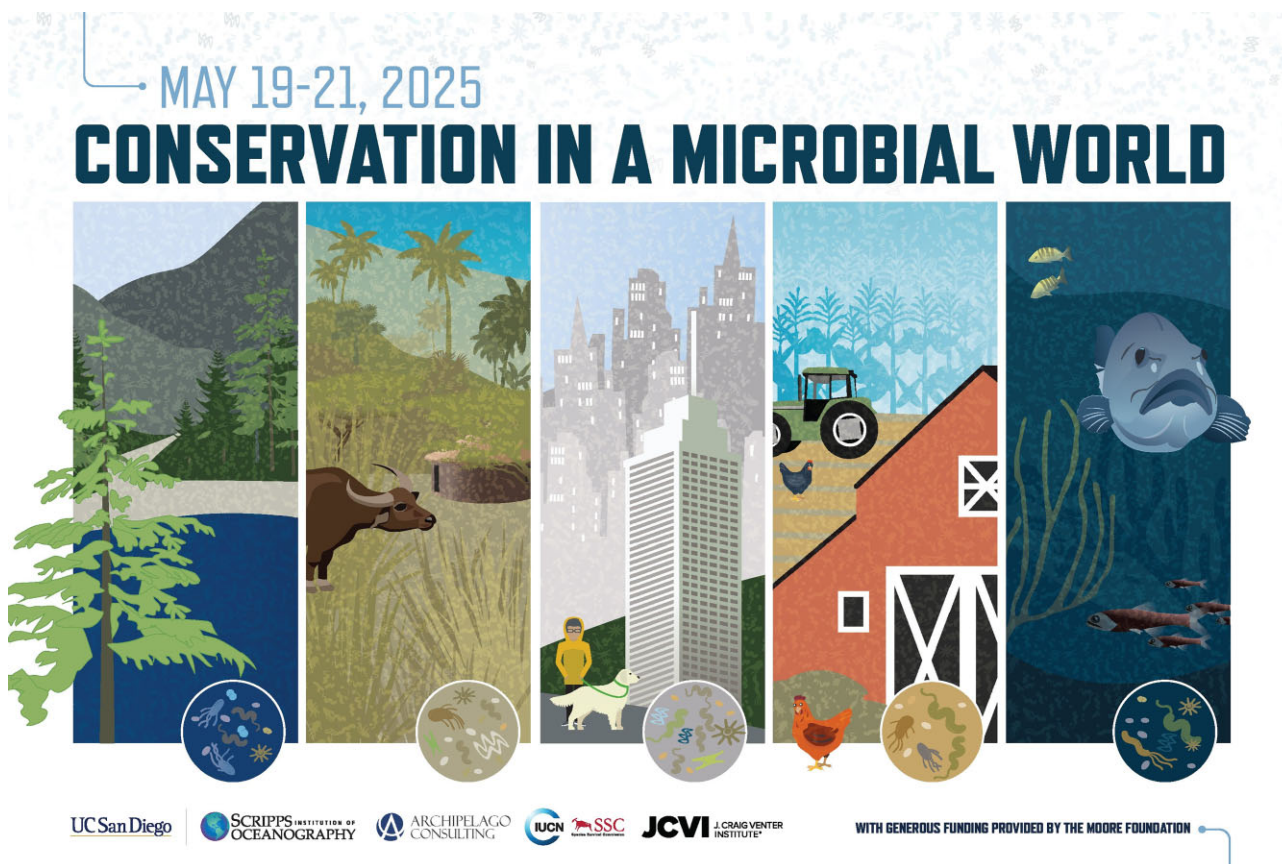


Figure 1. Conference Graphic. Created by J. Matthews, UC San Diego.

of how SSCs can catalyze evidence-based conservation, and details about the existing SSC groups that include a microbial component. Speakers included the IUCN Chief Scientist (Dr. Thomas Brooks), the Chair of the IUCN SSC (Dr. Jon Paul Rodríguez), and chairs from both the IUCN SSC Invertebrate Conservation Committee (Dr. Axel Hochkirch) and the IUCN SSC Fungal Conservation Committee (Dr. Gregory Mueller). Finally, presentations highlighted where preservation of microbes is already occurring such as the Leibniz Institute DSMZ (<https://www.dsmz.de/>), the Microbiota Vault (<https://www.microbiotavault.org/>), and the San Diego Wildlife Alliance Wildlife Biodiversity Bank as well as the relevant international policy frameworks that impact microbial research and conservation. The meeting successfully bridged multiple efforts to identify areas of strength and activity for a potential IUCN Specialist Group for Microbes.

In the bacterial and archaeal domains of life, conservation may look a bit different than that familiar for the macrobial world. For one, these microbes cannot be seen with the naked eye. The species concept is especially difficult to apply to microbes (Bobay 2020), and while the proportion of species facing elevated extinction remains unknown, microbes may deliver important functional roles that may be at risk (for example, because of local extinction due to loss of habitat or host species, or loss of accessory genomic elements containing unique functions). The unique qualities of microbes raised various questions that were revisited throughout the meeting, breakout sessions, presentations, and informal conversations:

1. How can we convince policy makers and practitioners of the importance of something they cannot see?
2. How can we conserve microbes individually and as communities?
3. How can we use microbes to advance conservation strategies?

There were deep dives into each of these categories, which the authors are defining as “Conservation of Microbes” and “Use of Microbes in Conservation.”

Conservation of microbes

Several ecosystems were highlighted throughout the first day of the conference, each demonstrating significant interest areas for microbial conservation, and were thus deemed priority areas for targeted microbial conservation efforts. The opening day featured a series of short talks spotlighting natural environments with distinctive microbial communities. In Mexico’s Cuatro Ciénegas Basin, Dr. Valeria Souza presented the case of endemic microbial lineages of Bacilli and Archaea-rich mats (Cisneros-Martínez et al. 2023), which are tied to early Earth evolution. However, the increased extraction of groundwater for agriculture has already led to major biodiversity loss in the area. The Churince system, a key spring-fed wetland within Cuatro Ciénegas that supported numerous endemic microbial and aquatic species, dried out in 2016 (Souza et al. 2018). The Archaean Domes, another microbially rich site in the region, are thought to have experienced similar drying in 2023, though their current status remains uncertain. Dr. Antje Boetius then turned to the Arctic, Antarctic and high mountain cryosphere, showcasing the unique diversity and endemism of cold-adapted microbial communities that are crucial for polar food webs and carbon cycling (Boetius et al. 2015), but that

are disappearing rapidly due to warming. Dr. Chris Dupont highlighted how marine microbiomes overall help to regulate oxygen production and climate stability, yet the presence of dead zones (hypoxic zones of water) and nutrient pollution threatens their function. Dr. Fengping Wang introduced the vast unique microbes present in the deep ocean with important ecological and geochemical functions, yet their presence might be threatened by increasing anthropogenic activities. From the land, Dr. Karsten Zengler emphasized how soil microbial systems, which are foundational to plant health and global carbon storage, are also facing a similar threat as they remain poorly protected. Dr. Sue Ishaq wrapped up the case studies session by introducing the concept of microbiome stewardship, emphasizing that microbial communities are deeply embedded in ecological and social systems and should be governed with long-term, equitable conservation in mind (Ishaq et al. 2021).

Microbial conservation was explored not just as a theoretical ambition but as an operational reality through institutional infrastructures like the DSMZ and San Diego Wildlife Alliance Wildlife Biodiversity Bank (Benirschke 1984) and initiatives such as the Microbiota Vault (Dominguez-Bello et al. 2025). Dr. Amber Scholz presented DSMZ as a cornerstone of microbial preservation, housing over 90 000 living resources, including bacteria, archaea, fungi, and genetic materials. These collections are essential to taxonomy, reproducibility, and the long-term integrity of microbial science. She also brought up how they comply with legal frameworks like the UN Convention on Biological Diversity's Nagoya Protocol, setting a precedent for ethical and equitable use of genetic resources. Dr. Maria Gloria Domínguez-Bello highlighted the Microbiota Vault, a global initiative inspired by the Seed Vault model that aims to safeguard microbial heritage, particularly those at risk in biodiverse but vulnerable regions. With physical and digital repositories being established around the world, and sample collections spanning stool, fermented foods, and environmental microbiota, the Vault exemplifies literal microbial conservation in action. These efforts reflect a commitment to treating microbes not just as tools or data, but as living components of global biodiversity requiring protection, infrastructure, and policy.

Microorganisms are critically important for oxygen production, chemical cycling, climate change mitigation, and plant, animal and human health, and therefore require protection across all ecosystems.

Use of microbes in conservation

Another rationale for microbial conservation raised at the meeting was the role of microorganisms in sustaining **macroorganisms** and regulating climate. Across terrestrial and marine systems, macroorganisms harbor symbiotic, host-associated microbiomes; thus, conservation of a macroscopic species can be strengthened if its resident microbiota are also considered. In fact, almost no species can be raised germ-free without dramatically impacting its phenotype. Numerous studies have demonstrated how inter-individual variability in host-associated microbiomes can be linked to variations in the health status of their respective hosts. This suggests the potential of microbial introductions and interventions as a way to track or even reverse declines in macrobial organisms of interest. For example, Dr. Raquel Peixoto presented research showing that probiotics have been successfully used on corals to

mitigate heat stress and reduce bleaching-associated mortality (Santoro et al. 2021) and that this approach is already being tested in the real world (Delgadillo-Ordoñez et al. 2024), with health and/or microbiome improvements for both corals and other reef organisms (Ribeiro et al. 2024, Duarte Rosado et al. 2025). Dr. Colin Averill demonstrated how active transplantations of native soil microbiomes can markedly accelerate plant biomass production, making this a potential cornerstone of forest restoration (Funga, PBC) (Averill et al. 2022). Dr. Janet Jansson discussed how microbial interventions may also help mitigate climate change, one of the largest drivers of biodiversity loss. For example, Dr. Karsten Zengler presented research indicating that synthetic microbial consortia can improve carbon capture in soil, serving as a climate mitigation strategy (Beattie et al. 2025). In sum, microbial symbionts are integral to eukaryotic biology and ecosystem function; consequently, explicit consideration of microbes can strengthen conservation strategies for eukaryotic species, and for ecosystems.

Leveraging the role of microbes in broader ecosystem health is one strategy identified by the group to get policy makers and practitioners interested in microbes. In addition to launching a campaign for the “microbe curious”, meeting participants identified storytelling as a great way to get microbes into the conservation narrative.

Outcomes and action items

The immediate outcome of the meeting is the establishment of an IUCN SSC—MCSG. This specialist group will be the first ever to address extinction of microorganisms. A proposal was drafted immediately after the meeting, synthesizing key topics covered during the meeting, including key stressors to microbes, the importance of including microbes in conservation efforts, and how microbes fit into other Specialist Groups focused on eukaryotic species. The establishment of this new Specialist Group has now been approved by the IUCN SSC Steering Committee, and the MCSG was launched in June 2025 (Gilbert et al. 2025). Co-chair of this group is Dr. Raquel Peixoto, the pioneering female scientist already well-known for her efforts to highlight the importance of microbes in global biodiversity (Peixoto et al. 2022). It was agreed that this Specialist Group should bring in diverse perspectives from various disciplines and represent global demographics. The proposal advances four immediate action items: (i) convene a network of experts at the interface between microbiology and conservation, with a specific focus on participants from the Global South; (ii) identify and prioritize the top microbial diversity hotspots for targeted conservation; (iii) explore integration of microbes into the IUCN Red List frameworks; and (iv) develop safety guidelines for the use of engineered or transplanted microbes in conservation. Additional priorities for the MCSG include securing sustained funding and launching a broad communication campaign. Revive & Restore, a nonprofit wildlife conservation organization directed by meeting participant Ryan Phelan, has already secured funding and is launching a request for proposals to encourage new microbial research for conservation. Several participants committed to raising awareness through accessible news stories and social media. Importantly, the IUCN World Conservation Congress is to be hosted in October 2025, just five months after this meeting, which offers a timely platform to present the value and implementation strategy for a MCSG to the wider conservation community.

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Author contribution

Emily Kunselman (Conceptualization [equal], Writing – original draft [equal], Writing – review & editing [equal]), Vanessa Minnis (Conceptualization [equal], Writing – original draft [equal], Writing – review & editing [equal]), Sho Kadera (Conceptualization [equal], Writing – original draft [equal], Writing – review & editing [equal]), Mary M. Buschmann (Writing – review & editing [equal]), Adam Jones (Writing – review & editing [equal]), Alexander Dehgan (Writing – review & editing [equal]), Amber Hartman Scholz (Writing – review & editing [equal]), Antje Boetius (Writing – review & editing [equal]), Axel Hochkirch (Writing – review & editing [equal]), Chris Dupont (Writing – review & editing [equal]), Chris Walzer (Writing – review & editing [equal]), Colin Averill (Writing – review & editing [equal]), Drew Endy (Writing – review & editing [equal]), Fabrice Stephenson (Writing – review & editing [equal]), Fengping Wang (Writing – review & editing [equal]), Gregory Mueller (Writing – review & editing [equal]), Janet K. Jansson (Writing – review & editing [equal]), Jon Paul Rodríguez (Writing – review & editing [equal]), Karsten Zengler (Writing – review & editing [equal]), Kent H. Redford (Writing – review & editing [equal]), Louis-Patrick Haraoui (Writing – review & editing [equal]), Maria Gloria Dominguez Bello (Writing – review & editing [equal]), Miguel Lurgi (Writing – review & editing [equal]), Nadine Lamberski (Writing – review & editing [equal]), Neil Cox (Writing – review & editing [equal]), Raquel Peixoto (Writing – review & editing [equal]), Rob Knight (Writing – review & editing [equal]), Robert Friedman (Writing – review & editing [equal]), Ryan Phelan (Writing – review & editing [equal]), Sean M. Gibbons (Writing – review & editing [equal]), Suzanne Lynn Ishaq (Writing – review & editing [equal]), Thomas Brooks (Writing – review & editing [equal]), Valeria Souza (Writing – review & editing [equal]), Jack Gilbert (Conceptualization [equal], Writing – review & editing [equal]), Sarah Michelle Allard (Conceptualization [equal], Writing – review & editing [equal]).

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Data availability

No data were created or analyzed in this article.

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