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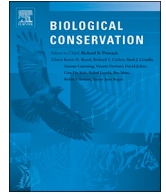
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Editorial

Impacts of the coronavirus pandemic on biodiversity conservation

1. Introduction

The COVID-19 pandemic is impacting all parts of human society. Like everyone else, conservation biologists are concerned first with how the pandemic will affect their families, friends, and people around the world. But we also have a duty to think about how it will impact the world's biodiversity and our ability to protect it, as well as how it might affect the training and careers of conservation researchers and practitioners. As editors of *Biological Conservation*, we have heard first-hand from colleagues, authors, and reviewers around the world about the problems they are facing, and their concerns for their students, their staff, and their research projects. Some of our colleagues have become infected with the virus. Field and lab work have largely shut down, while teaching and other communications have moved online, with consequences for training, data collection, and networking that are still unclear. Our colleagues and the media report some examples of reduced human pressures on natural ecosystems, cleaner air and water, and wildlife reclaiming contested habitats. Beyond the direct and immediate consequences of this particular virus, some have also started to think about emerging infectious diseases and their links with biodiversity loss, human activities, and issues of sustainability.

As we write this, the pandemic is still accelerating in most countries, although there are hopeful signs of returns to normality in, for example, China. This editorial can therefore only be a snapshot of a quickly evolving situation. We hope, however, that we can offer some encouragement and insights for our colleagues in lockdown. Our world is changing, and the conservation community must be ready to respond.

2. Protecting conservation biology and biologists during and after the pandemic

2.1. Adapting education

Across the world, universities and research institutes have shut down. As with other subjects, courses critical to the training of conservation biologists and managers are being cancelled or moved online. In practice, this means that professors with little prior online teaching experience are now teaching students with little experience in online learning. This can work well for some topics, but conservation is an applied science, like medicine, and students will miss the practical, hands-on experiences gained through labs and field courses. The consequences will depend on how long the shut-down continues and whether practical components of their training can be postponed until later.

Many career-relevant decisions made in the field of conservation are affected by the COVID-19 pandemic. Exams have been postponed and the award of degrees and certificates has been delayed. There has been

a huge decline in advertising new jobs and interviewing for those previously advertised. Major research projects are on hold or cancelled, and associated employment opportunities lost, at least for now. Many researchers are continuing to employ students and technicians to work remotely on data analysis, digitizing paper records, coding interview transcripts, annotating photos and videos, or other tasks, but this is only a small part of conservation-related research and cannot continue for long.

The careers of tenured staff will survive if their institutions do, and students may be able to make up missed courses, but conservation also supports—and is supported by—numerous people who depend on temporary jobs in the field or lab. Early career scientists, such as graduate students and post-docs, need these jobs, both as a source of income and for the varied experiences they provide. For these young conservation scientists, financial worries interact with the problem of missed field or lab research. For some, these missed opportunities can be made up, although they may lead to delays of many months, but for others the damage will be irreversible, because of the nature of their research or their funding constraints.

Many conservation organizations, both governmental and some NGOs, recruit large numbers of seasonal employees, as short-term local contractors, student interns, and volunteers, to carry out fieldwork, environmental education, trail maintenance, and other activities. These positions are an important source of training, experience, and income for people in the field of conservation biology. The pandemic currently makes it impossible for many organizations to interview, hire, train, house, and supervise seasonal staff. Unless lock-down measures are reduced dramatically in the next couple of months, a whole cohort of students may therefore miss out on these opportunities.

Delays in training and career development, in combination with the economic and psychological impacts of the COVID-19 pandemic, may cause some people to leave the field of conservation biology and pursue other careers that offer more stability or better pay. If the pandemic lasts into the next academic year, declining enrollments at universities, and in conservation and ecology courses, may have longer-term negative consequences. More optimistically, education and research in ecology, conservation, and environmental studies may appear more attractive and meaningful to young people who have been alerted to the global environmental crisis by this pandemic and made aware of the links between biodiversity conservation and human well-being.

2.2. Maintaining research

University laboratories and other research facilities have shut down, ending many lab-based experiments and halting new research. Field research has been similarly impacted, with many field sites no longer accessible, because of travel and entry restrictions, and safety concerns.

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International travel has become all but impossible, and post-pandemic recovery may be slow if countries maintain entry restrictions. Researchers can no longer conduct field-based social research that requires interviews or focus groups, because of the possibility of disease transmission. Oceanographic research cruises have also been cancelled, many permanently because of the difficulty of re-scheduling ship time. The impact of losing these expeditions is high, because the locations to be explored are typically remote and under-studied.

Missed research means missed opportunities to identify conservation priorities, monitor the health of endangered species and ecosystems, and provide practical solutions for the protection and sustainable use of resources on which human well-being depends. As with many concerns discussed here, the impact will depend on how long shutdowns last and whether research projects are simply postponed or permanently cancelled. Gaps in a long-running time series cannot be filled later but may not be serious if observations are restarted soon. A lot of conservation research nowadays involves data collection by citizen scientists. Most of this will be stopped for now, but it is important that conservation researchers keep in touch with citizen participants and, where possible, provide alternative activities. For example, backyard bird counts and web-based projects may receive increased attention.

The looming global economic recession will reduce funds available to national governments and conservation foundations, and potentially reduce funding for research grants and conservation programs. Projects funded by the Inter-American development bank (IDB) and the Global Environment Facility (GEF), for example, are now requesting a formal risk analysis related to the pandemic to assess whether and by how much the projects they fund will be impacted by the virus. Conservation research is unlikely to be a government priority during the post-pandemic economic recovery, and conservation biologists must communicate the many benefits that both this research, and biodiversity itself, provide society. Organizations reliant on external donors to employ staff and implement research and conservation activities will be particularly vulnerable.

2.3. *Adjusting communication and networking*

One immediate consequence of the pandemic is that conservation and ecology meetings of all sizes have been cancelled for the next few months, and probably even longer. For many small to medium-sized gatherings, online conferencing technology might provide an effective way for people to meet and exchange ideas. For large conferences—like those held by the Society for Conservation Biology and the Ecological Society of America—involving many thousands of people, online meetings cannot replace the networking and interactions that happen at the in-person conferences. In face-to-face meetings, large venues provide unique opportunities to meet a wide range of people with varied expertise, to explore and learn about the latest developments in the field, and to get feedback on one's own projects. Such meetings also are places to reconnect with previous colleagues and collaborators, meet future collaborators and find colleagues who are mutually compatible. A missed conference is a minor concern for established individuals, but for graduate students and early career researchers and practitioners it can be a major loss. The current crisis creates both needs and opportunities for conservation science to communicate more online. Online communications can, for example, draw attention to the links between conservation and human well-being, test models for alternative events, funding, and educational measures, and make meetings more accessible to a larger community.

It is not only academic meetings that are threatened. Two key global intergovernmental meetings planned for 2020 are crucial to addressing the twin environmental crises of our time: biodiversity loss and climate change. The Convention on Biological Diversity (CBD) COP 15 was scheduled to take place in Kunming, China, in October and has now been postponed, with no new date announced as we write this. The

purpose of this meeting was to establish a post-2020 global biodiversity framework, and its postponement means that key decisions will be delayed and may have less impact. Similarly, the UN climate change conference COP 26, planned for November in Glasgow, has been postponed, with potentially serious consequences for international efforts to address the challenges of climate change. As the world recovers from the pandemic, we must keep reminding our governments how important ambitious commitments at these two meetings are.

3. **Protecting biodiversity during and after the pandemic**

3.1. *Biodiversity now*

How is the pandemic affecting biodiversity now? It is too early for a definite answer, but communications with our colleagues around the world suggest that essential conservation work is still going ahead. National parks and protected areas in many places are still being patrolled and vulnerable wildlife is still being guarded. This continued protection is a testament to the dedication of protected area staff during an extraordinarily difficult time. There may be problems we have not heard about, but on current evidence, practical conservation appears to be continuing in many places.

There have even been anecdotal reports of reduced human pressures on wild species. In protected areas, declines in visitor numbers caused by travel restrictions and park closures have reduced stresses on sensitive animals and trampling pressure on popular trails. Conservation derives much of its public support from the accessibility of wild nature in protected areas, but reduced human pressures in the most popular parks will be good for sensitive species. We have also seen reports of wild species venturing into rural and urban areas, including parks and beaches, where they have not been seen for many years, as traffic and other human activity declines. In areas where travel is still possible and protected areas remain open, visitation has often greatly increased, reflecting a widespread feeling that activity in a natural setting is both a physical and a mental antidote to the stress of the pandemic. We predict it will increase in other areas too when restrictions are loosened.

Satellite images have shown dramatic improvements in air quality in every country affected by the pandemic, as industry and transport shut down (Fig. 1). Shipping has declined worldwide and reduced impacts on marine systems might be expected. This year will very likely see a global decline in greenhouse gas emissions, as well as large reductions in other drivers of global warming, such as the contrail cirrus from high-flying aircraft. These may be short-term improvements, but they dramatically underline the pervasiveness and severity of anthropogenic impacts worldwide.

3.2. *Conservation going forward*

The positive impacts listed above are all likely to be temporary and it is currently not clear how conservation will fare in the aftermath of the pandemic. Noise, air, and water pollution, greenhouse gas emissions, and the many other adverse human impacts on wild nature will rebound, but funding and other support for conservation will have to compete with a wide range of new priorities for financial resources which are likely to be reduced overall, at least in the near future. Conservation NGOs may also struggle to raise funding from private sources. Ultimately, conservation depends on boots on the ground and, if funding is limited, it is these activities that will need to be prioritized.

On the other hand, if conservation must compete for resources, we may find that we have new allies. Experts in emerging infectious diseases have been warning for decades that habitat fragmentation and degradation, and live animal markets, increase the risk of diseases spilling over from wildlife into human populations. The emergence of many of the new scourges of our time—HIV, Ebola, Nipah, SARS, H5N1 and others—can be attributed, at least in part, to increased human impacts on natural systems. China has already taken the first steps

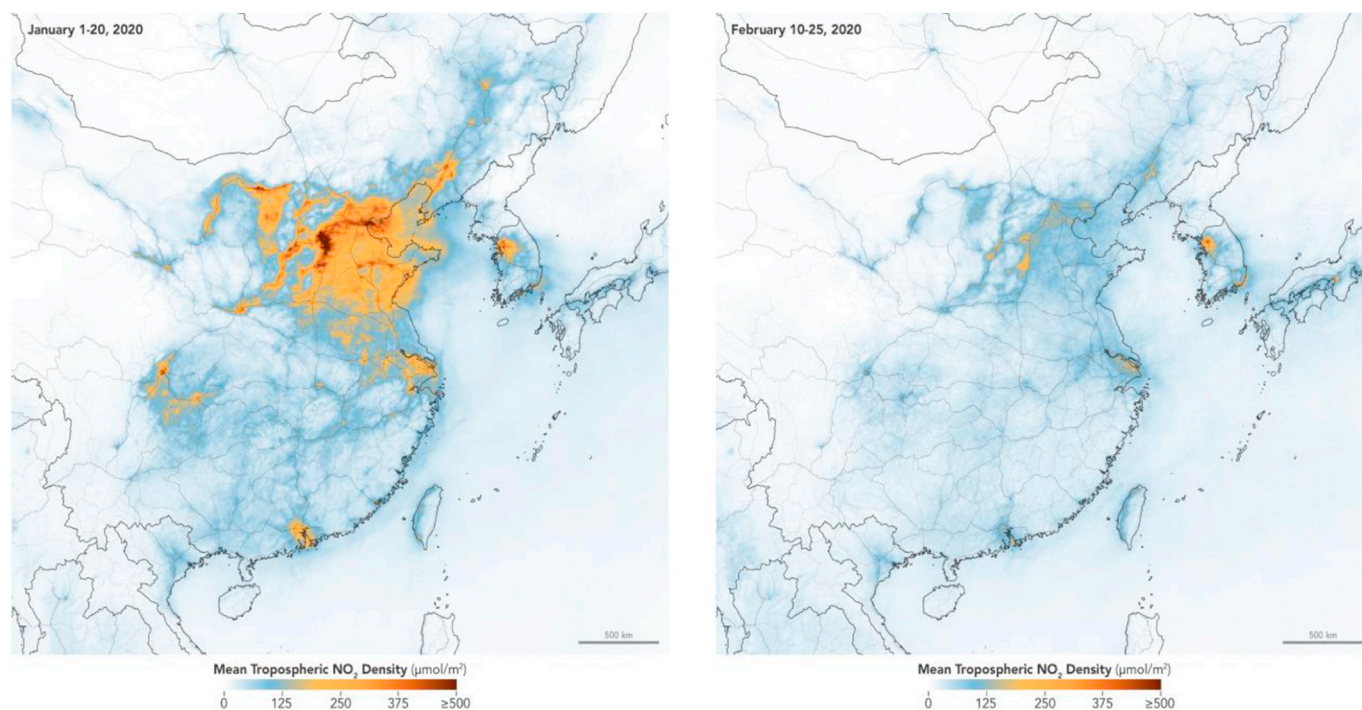


Fig. 1. Concentrations of nitrogen dioxide across eastern China from January 1–20, 2020 (before the COVID-19 quarantine) and February 10–25 (during the quarantine).

Data collected by the Tropospheric Monitoring Instrument (TROPOMI) on ESA's Sentinel-5 satellite. NASA Earth Observatory images by Joshua Stevens, using modified Copernicus Sentinel 5P data processed by the European Space Agency.

towards ending the trade in live wild animals, but this needs a permanent and enforceable global agreement. And what if people's appreciation for vital ecosystem services such as clean air and water has grown, and they notice pollution when it reappears? This would provide an opportunity to push for stronger clean air and water regulations and better enforcement of existing regulations. Increasing visits to protected areas could be bad for sensitive species, but increasing support for the protected area system would be good news in the longer term.

The inevitable uncertainties at this stage mean that the conservation community must be ready to respond to needs as they become apparent. We think the priority will usually be supporting people: ensuring that early career researchers and practitioners, on whom future conservation depends, have opportunities to continue their careers and grow their contributions to the field. But we must also be ready to respond to positive new trends, to reach out to potential new allies, to step up public education, and to be available with the science when it is needed. Research may need to be triaged; we should probably focus on the highest priority protection, including species recovery and enforcement, but in a way that minimizes negative impacts on education and career development.

4. Stimulating opportunities for conservation research and practice

Our journal *Biological Conservation* exists to advance the science and practice of conservation. The pervasive impacts of the pandemic on all aspects of human society present research opportunities that would not otherwise have occurred. While some socio-ecological systems will eventually return to their pre-pandemic states, others may be permanently altered. A single global event does not allow for a replicated design, but standardized measurements before, during, and after the pandemic can make up for this. Researchers who have been studying systems prior to the coronavirus pandemic are particularly well placed to monitor these systems during and after the crisis. In practice, we may

often have to make do with less than this ideal—re-purposing old observations and matching them with new ones as closely as practical—but this can also be valuable. Useful topics for investigation will depend on how the pandemic develops and will vary between locations, but we offer some possible examples here with the hope of inspiring others.

4.1. Impacts on research and conservation

What kinds of consequences will disruptions to field and lab work during the pandemic have for the species and ecosystems we are studying, monitoring, and protecting?

What effects will reduced human impacts on wildlife and ecosystems during the pandemic have on wild species (e.g. ranging behavior, breeding) and ecosystems, and will any of these effects persist into subsequent years?

Will conservation budgets be reduced because of the economic fallout from the pandemic, and how will this impact both staffing levels, and conservation science and practice?

Will the ban on the capture, trade, and sale of live wild animals for food in China lead to reduced hunting pressure and the recovery of populations in the wild?

How has the pandemic crisis impacted people whose livelihoods depend on conservation and ecotourism, especially local people who live near and inside protected areas?

4.2. Impacts on education, training, and networking

Will the career paths and prospects for the current cohorts of senior undergraduate and graduate students differ from those who came before and will come after them?

Will the current switch to online teaching for conservation science and related disciplines impact learning outcomes and will it have a long-term influence on how courses are taught in the future?

What role will innovations in online technology play in

conservation learning and science post COVID-19?

Will the move to other models for conferences and networking have a permanent impact on if and how traditional conferences are held, and will these new models affect how research collaborations develop?

Can lessons learned about online communication during the pandemic be used to reduce travel-related greenhouse gas emissions in the future?

5. Conclusions

It is too early to evaluate the overall impacts of the coronavirus pandemic on biodiversity and our ability to protect it, but some preliminary conclusions are possible. At this point, protected areas appear to be safe and, in many places, biodiversity is benefitting from reduced human activities. However, this may not be true everywhere, especially where enforcement has weakened but threats have not. Research has been disrupted, but only time will tell if this will have long-term consequences. We are concerned for the training and careers of young conservation scientists, but the lasting effects of the pandemic on these will depend, in part, on how we and our institutions respond to these concerns. Finally, although we focus here on conservation, this is first and foremost a human tragedy, disrupting lives and killing far too many people. Society's priorities must be human health and the containment of the pandemic, but we also need to be thinking ahead to the resumption of conservation practice and education. There is an opportunity here to remind people of the links between healthy, resilient ecosystems and human well-being.

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