

*Edited by*

JOACHIM VON BRAUN, THOMAS KAUFFELS, PETER RAVEN,  
JOHANNES VOGEL, MARCELO SÁNCHEZ SORONDO

# SCIENCE AND ACTIONS FOR SPECIES PROTECTION

## Noah's Arks for the 21st Century



**Science and Actions  
for Species Protection.  
Noah's Arks for the 21st Century**



*The Proceedings of the Conference on*

# Science and Actions for Species Protection. Noah's Arks for the 21st Century

*13-14 May 2019*

*Edited by*

Joachim von Braun

Thomas Kauffels

Peter Raven

Johannes Vogel

Marcelo Sánchez Sorondo



EX AEDIBVS ACADEMICIS  
IN CIVITATE VATICANA • MMXX

The Pontifical Academy of Sciences  
Casina Pio IV, 00120 Vatican City  
Tel: +39 0669883195 • Fax: +39 0669885218  
Email: pas@pas.va • Website: www.pas.va

The opinions expressed with absolute freedom during the presentation of the papers of this meeting, although published by the Academy, represent only the points of view of the participants and not those of the Academy.

ISBN 978-88-7761-098-0

© Copyright 2020

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form, or by any means, electronic, mechanical, recording, photocopying or otherwise without the expressed written permission of the publisher.

PONTIFICIA ACADEMIA SCIENTIARVM  
LIBRERIA EDITRICEVATICANA

VATICAN CITY



“The earth’s resources are also being plundered because of short-sighted approaches to the economy, commerce and production. The loss of forests and woodlands entails the loss of species which may constitute extremely important resources in the future, not only for food but also for curing disease and other uses. Different species contain genes which could be key resources in years ahead for meeting human needs and regulating environmental problems. It is not enough, however, to think of different species merely as potential ‘resources’ to be exploited, while overlooking the fact that they have value in themselves. Each year sees the disappearance of thousands of plant and animal species which we will never know, which our children will never see, because they have been lost for ever. The great majority become extinct for reasons related to human activity. Because of us, thousands of species will no longer give glory to God by their very existence, nor convey their message to us. We have no such right”.

Pope Francis, *Laudato Si'*, §§ 32-33.









# Contents

▶ <b>I. INTRODUCTION, OVERVIEW AND RECOMMENDATIONS FOR SCIENCE AND ACTIONS</b> Joachim von Braun, Thomas Kauffels, Peter Raven, Johannes Vogel, and Marcelo Sánchez Sorondo .....	12
▶ <b>II. LESSONS AND INSIGHTS FROM NATURAL HISTORY MUSEUMS' RESEARCH AND OUTREACH</b>	
1. <b>Towards a 21st Century Open and Integrated Natural History Museum</b> Maïke Weißpflug and Johannes C. Vogel .....	25
2. <b>What Future without Nature? How Natural History Could Help</b> Bruno David .....	39
3. <b>Fostering Community Engagement with Nature at the Natural History Museums of Los Angeles County</b> Gregory B. Pauly, Brian V. Brown, and Lori Bettison-Varga .....	46
4. <b>History in Action: the Role of Natural History Museums in Conservation</b> Richard W. Lariviere .....	61
▶ <b>III. LESSONS AND INSIGHTS FROM ZOOLOGICAL GARDENS' RESEARCH AND OUTREACH</b>	
5. <b>The Context of Zoos and Aquariums</b> Thomas Kauffels .....	69
6. <b>Zoos and Public Conservation Education</b> Gloria Svampa Garibaldi .....	78
7. <b>Zoos Mobilizing the Public for Legislative Change</b> Theo B. Pagel .....	89
8. <b>Zoo-Led Science and the Global Conservation of Species</b> Mark Pilgrim .....	100
9. <b>Zoos: Connecting People with Nature and Wellness Building</b> María Clara Domínguez Vernaza .....	105

▶	<b>IV. LESSONS AND INSIGHTS FROM BOTANICAL GARDENS' RESEARCH AND OUTREACH</b>	
10.	<b>Plant Conservation: Challenges and Opportunities</b>	
	Peter Raven.....	113
11.	<b>The Center for Plant Conservation Model to Urgently and Effectively Conserve North American Plants</b>	
	John R. Clark.....	124
12.	<b>Can Botanic Gardens Conserve All of the World's Rare and Threatened Plant Species?</b>	
	Paul P. Smith.....	131
13.	<b>Conservation-Oriented Restoration as a Primary Solution</b>	
	Sergei Volis.....	141
14.	<b><i>Erica verticillata</i>, from Extinction to Restoration</b>	
	Anthony Hitchcock.....	153
15.	<b>Technologies from Agriculture to Help “Noah” Save Plants</b>	
	Christina Walters.....	176
16.	<b>The National Collection of Colombia's Native Palms: a Testimony of Love for Planet Earth</b>	
	Alberto Gómez-Mejía.....	188
▶	<b>V. OVERARCHING ISSUES: SCIENTIFIC, MORAL/RELIGIOUS, AND POLITICAL ASPECTS OF SPECIES CONSERVATION AND HUMAN BEHAVIOR CHANGE</b>	
17.	<b>Policies in Ethiopia on Protection of Nature and Species</b>	
	Hailemariam Desalegn.....	197
18.	<b>Engaging Traditional Populations and Indigenous Peoples in Biodiversity Conservation through Amazon Bioeconomy</b>	
	Virgílio Viana.....	205
19.	<b>Conserving the Diversity of Life: A Moral Duty and Imperative for Equitable Development</b>	
	Marco Lambertini.....	214

---

<b>20. Community Authority and the Signals of Science: Next Steps in Furthering the Impact of Biodiversity Conservation Science</b>	
Philippa Jane Benson .....	224
<b>21. Plants and Nature in Bible and Quran – How Respect for Nature Connects Us</b>	
Wilhelm Barthlott .....	233
<b>22. From a Sea-Snail to the Heavenly Throne: Wild Fauna in Jewish Law and Spirituality</b>	
Y.M. Barilan and Yehoshua Weisinger .....	245
<b>23. Climate Crisis and Hope</b>	
Mikkel Wold.....	258
<b>LIST OF PARTICIPANTS.....</b>	<b>269</b>

# I. Introduction, Overview and Recommendations for Science and Actions

JOACHIM VON BRAUN, THOMAS KAUFFELS, PETER RAVEN,  
JOHANNES VOGEL, AND MARCELO SÁNCHEZ SORONDO

## Introduction and objectives of the volume<sup>1</sup>

The Papal encyclical *Laudato si'* represents a strong critique of modern consumerism and its catastrophic effects on biodiversity. It warns us about the planet's endangered ecology and points to the need for science and politics to engage with religious and moral authorities to review the current situation and propose joint strategies aimed at changing the trajectory of humankind. In principle, all major world religions are committed to respecting and preserving human dignity and nature and can agree on joint actions for this objective.

The subtitle “Noah’s Arks for the 21st Century” refers to the Bible’s story of the destructive flood and Noah rescuing humankind and species with his ark following God’s order (6–9). Today, our common fascination with nature leads us to preserve species threatened by manmade environmental destruction, including climate change and the related loss of species, in zoological and botanical gardens. In these, as well as in natural history museums, endangered and/or extinct species can be studied, so that conservation can have a sound basis. We understand that these attempts to build “Noah’s Arks for the 21st century” may not be sufficient to prevent the threats of global loss of species by building and studying islands of protection. The worldwide communities managing natural history museums, zoological and botanical gardens engage in research as well as inspire millions of visitors. They are ideally placed to act as conveners, change agents and pace-makers, as catalytic and significant allies in the global drive toward species protection nature preservation and nature on our planet.

<sup>1</sup> The contributions by Katharina Gallant (Center for Development Research, ZEF, Bonn University) to the careful editing of the volume and her substantive advice for improving the volume are gratefully acknowledged. Similarly, the support for organization of the conference on which this volume is based and all related arrangements by the Chancellery of the Pontifical Academy of Sciences, and by Simonetta Ulisse in particular, is gratefully acknowledged.

The Pontifical Academy of Sciences has addressed these challenges before, i.e. with conferences on

- Biological Extinction – How to Save the Natural World on Which We Depend, PAS-PASS Workshop 2017<sup>2</sup> and the corresponding edited volume that emerged from this event;<sup>3</sup>
- Health of People and Planet: Our Responsibility, PAS-PASS Conference 2017, with a focus on climate change;<sup>4</sup>
- Science and Sustainability. Impacts of Scientific Knowledge and Technology on Human Society and Environment, PAS Plenary Session 2016;<sup>5</sup>
- Sustainable Humanity, Sustainable Nature: Our Responsibility, PAS-PASS Workshop 2014;<sup>6</sup>
- Evolving Concepts of Nature, PAS Plenary Session 2014.<sup>7</sup>

The conference from which the papers of this volume derived drew on these earlier conferences and related statements by the Academy, and takes note of consultations related to the topic, such as (1986).<sup>8</sup>

We note at the outset that the global context of species extinction and loss of biodiversity in the Anthropocene is a consequence of human actions, competition for land and water use, global environmental change, and climate change in particular, as elaborated in the above-mentioned PAS conferences. During these conferences it has been estimated repeatedly that about one fifth of all non-bacterial organisms will be in danger of extinction in the next few decades, and as many as half of them by the end of the 21st century. These insights provide the background of this conference.

The different focus of this PAS conference and its expected contribution was to bring together the three important communities that engage in science and action for biodiversity and species protection under the umbrella of the Academy; i.e., partners from natural history museums, zoological and botanical gardens. All three of these communities combine research on conser-

<sup>2</sup> <http://www.pas.va/content/accademia/en/events/2017/extinction.html>

<sup>3</sup> <http://www.pas.va/content/accademia/en/publications/scriptavaria/extinction.html>

<sup>4</sup> <http://www.pas.va/content/accademia/en/events/2017/health.html>

<sup>5</sup> [http://www.pas.va/content/accademia/en/events/2016/science\\_and\\_sustainability.html](http://www.pas.va/content/accademia/en/events/2016/science_and_sustainability.html)

<sup>6</sup> <http://www.pas.va/content/accademia/en/events/2014/sustainable.html>

<sup>7</sup> <http://www.pas.va/content/accademia/en/events/2014/nature.html>

<sup>8</sup> <http://www.arcworld.org/downloads/THE%20ASSISI%20DECLARATIONS.pdf> (last accessed on October 28, 2019).

vation and species protection with communication and educational activities, reaching millions of people, including youth. Combining elements of political engagement, public education and conservation knowledge and action, the global communities of natural history museums, zoological and botanical gardens are positioned exceptionally well to bring together stakeholders for a conference that leverages the strengths of science and social and spiritual engagement to propose actions that can reach large populations worldwide. Each community can do so from a different and complementary angle:

- *Natural history museums.* Natural history museums and natural history collections are the key to learn about nature – its past, its present, and its future. Several thousand organizations worldwide have assembled billions of specimens and associated information. These collections are a unique and truly global scientific infrastructure for science and society as well as the source of much of the information upon which effective conservation action can be based. These collection-based, cutting-edge research institutes also attract millions of visitors every year. Gaining in number and scope in the 18th century Age of Enlightenment, they have been reaching people of all ages and classes, instilling a deep love for nature and nurturing scientific inquiry and curiosity for more than four centuries.
- *Zoological gardens.* The European Association of Zoos and Aquaria (EAZA), and other regional and global zoos maintain high-level contacts with local, national and regional legislators, global conservation bodies and in situ conservation projects, zoological researchers, educational institutes, and organizations with a similar interest in learning about and preserving biodiversity. Campaigns run by EAZA and similar associations point to a strong social justice agenda whereby the preservation of biodiversity must also support the development of communities in biodiverse regions globally, providing education and alternative solutions to the conservation challenges of the modern age, from human/wildlife conflict to the exploitation of the natural world for extrinsic gain at all levels.
- *Botanical Gardens.* Botanical gardens, which were first established in modern times as adjuncts to medical schools during the Italian Renaissance in the early 16th century, and began to conduct research about two centuries ago. Plant systematics and evolution are studied mostly in botanical gardens, natural history museums, and universities, ultimately providing the factual basis on which plant conser-

vation can be carried out. Today, botanical gardens are deeply concerned with the need to protect biodiversity, and express that concern through their displays and educational programs. Because of the ability of plant seeds and tissues to be stored for decades or even centuries at low temperatures and then give rise to new individuals, plants are easier to preserve than most groups of animals. Botanical gardens and other institutions take full advantage of that fact.

The format of this edited volume offers each of the three communities the opportunity to present their cutting-edge research and communications outreach activities. In addition, this volume explores new synergies among these communities for enhanced impact on people's worldviews and new collective actions to address the problems of biodiversity loss and species extinction. This endeavor was undertaken together with members of the Pontifical Academy of Sciences and includes the critical assessment of potentials and challenges of building "Noah's Arks" in our times, thus comprising new virtual and practical approaches and engagement of different faith communities.

### **Overview of the volume**

This edited volume comprises four main sections that reflect the thematic foci of the conference and concludes with the final conference statement.

Section II focuses on lessons and insights from natural history museums, concentrating the ways in which they can foster conservation. Bruno David makes a strong point in favor of natural history museum's ability to engage in debates with the public, thus making complex topics at the intersection of the natural and social sciences understandable to a broad audience (Chapter 2). Gregory B. Pauly, Brian V. Brown, and Lori Bettison-Varga go one step further, presenting the Natural History Museum of Los Angeles County as a model of fostering community engagement with nature in an urban environment. The Museum bases their efforts on community-wide biodiversity surveys and related outreach programs (Chapter 3). Similarly, Richard W. Lariviere highlights the importance of mobilizing the audience of natural history museums and, in so doing, advocates for a translation of science through interpretation and action (Chapter 4). In the concluding section, similar examples are presented for Africa (Chapter 18), the Amazon (Chapter 19), and globally (Chapters 20 and 21).

The third section presents lessons and insights from zoological gardens, focusing on diversity standards and highlighting their role in contributing to Noah's Arks in the 21st century. Thomas Kauffels elaborates on the roles of zoos throughout history, as they have evolved from sites of individual



collections of animals to networks that effectively foster science, cooperative breeding, and outreach to the public to promote biodiversity and conservation (Chapter 6). The ways in which zoos serve both as recreational sites and centers for public education were further developed by Gloria Svampa Garibaldi (Chapter 7). Theo Pagel assesses how zoological gardens can use their immense popularity to educate and involve their public and, in doing so, create wide support for conservation (Chapter 8). Mark Pilgrim uses the Eastern black rhinoceros to outline the ways in which zoos foster the coordination of in situ and ex situ efforts to achieve the best possible conservation outcomes (Chapter 9). María Clara Domínguez Vernaza focusing on Colombia, argues for a close linkage between conservation the sustainable development goals (SDGs). By doing so with care, it is possible to support conservation in the context of improving human welfare, finding ways to enhance the welfare of deprived people (Chapter 10).

Section IV addresses the key role of botanical gardens in conservation. Introducing this section, Peter Raven reflects on ways in which the global network of botanical gardens is responding to the immense pressures humanity is putting on global sustainability. He calls for wide collaboration to bring about political change in the context of morality and social justice to achieve global sustainability and thus ameliorate the impact of the world's Sixth Major Extinction Event (Chapter 11). John R. Clark describes the activities of the U.S.-Canada-based Center for Plant Conservation in effectively conserving the plant diversity of these countries both in situ and ex situ – a worthy example for other regions and nations (Chapter 12). On a global level, Paul P. Smith describes the activities of Botanic Gardens Conservation International, which works by improving the capacity of its thousands of members to conduct effective conservation programs, both concrete and educational (Chapter 13). Alberto Gómez-Mejía describes the successful efforts of the Quindío Botanical Garden in Colombia both in assembling a significant collection of the nation's palm species, most of them endangered, and at the same time in employing that collection to enhance the public awareness of the importance of conservation (Chapter 17). The possibilities for combining the restoration of communities with the conservation of endangered plants are explored by Sergei Volis (Chapter 14), with an example of this sort, the South African (whorl heath) explained in detail by Anthony Hitchcock (Chapter 15). Finally, Chris Walters, by outlining the activities of the U.S. National Germplasm Center, shows how a major seed bank contributes in a very special way to plant conservation (Chapter 16). Of the world's 380,000 named plant species,

botanical gardens already cultivate some 110,000 species and seed banks and tissue culture centers hold some 70,000 already.

Finally, in Section V, this volume turns to the role of religions and faith, as well as national policies, in protecting the world's rich endowment of diversity. Regionally, Hailemariam Desalegn explains the Ethiopian policies on the protection of nature and species in the context of that nation's rich historical traditions (Chapter 18). For the Amazon, the subject of a fruitful synod held subsequently, Virgilio Viana provides a rich discussion of the possibilities of reconciling the living standards of the area's inhabitants with the core role that the natural ecosystems of the area play for them, for the survival of vast numbers of species, and for maintaining global sustainability (Chapter 19). That conservation is not only a moral duty but ultimately a question of survival is emphasized by Marco Lambertini (Chapter 20). Wilhelm Barthlott traces some of the modern foundations of this belief in the Holy Scriptures of the Abrahamic religions (Chapter 21). Y.M. Barilan and Yehoshua Weisinger focus on the role of biodiversity in the Jewish tradition, particularly as expressed in the familiarity with nature that religious obligations and rituals require (Chapter 22). In the final chapter of this volume, Mikkel Wold asserts powerfully that humankind must stay morally and spiritually connected to face these challenges with hope necessary to bring about change, citing the Papal Encyclical as a deeply meaningful explication of these relationships (Chapter 23).

In the following conference statement we have compiled the core messages of this fruitful meeting, including calls for improving our knowledge of biodiversity overall and then taking informed action to preserve it while there is still time to do so. Living in the opening decades of the Fifth Major Extinction Event, we must act promptly and with adequate strength. Spirituality and a belief in social justice can assist greatly in giving us that strength, and inspire us to act without delay.

### **Recommendations for SCIENCE AND ACTIONS<sup>9</sup>**

1. We have come together at this conference of the Pontifical Academy of Sciences including leaders from natural history museums, zoological gardens, botanical gardens, nature conservation specialists, and policy

<sup>9</sup> Concluding Statement of the conference by the Pontifical Academy of Sciences with international partners from Natural History Museums, Zoological Gardens, Botanical Gardens and Specialists in Biodiversity Protection, 13-14 May 2019. Casina Pio IV, Vatican City – May 15, 2019, prepared by Joachim von Braun with the conference partners and with inputs by conference participants.

advisors to call for action to build new sustainable relations between humanity and the natural world of which we are an integral part. We need to change our mindset, our mentality of exploitation that has driven us to the point where we are now. We seem to live in an immense and fantastic world, forgetting about what has been given to us. The encyclical *Laudato si'* by Pope Francis represents a strong critique of human impact on biodiversity: “Each year sees the disappearance of thousands of plant and animal species which we will never know, which our children will never see, because they have been lost forever. The great majority become extinct for reasons related to human activity. Because of us, thousands of species will no longer give glory to God by their very existence, nor convey their message to us. We have no such right” (Pope Francis, *Laudato si'*, § 33). The conference is a follow up to toward action by broad alliances. We take note and build on recent scientific conferences about the causes and consequences of extinction, such as the joint Pontifical Academies’ conference in 2017.<sup>10</sup>

2. An estimated one fifth of all life forms other than bacteria are in danger of extinction in the next few decades, and as many as half by the end of the 21st century; at least 80% of these species are unknown scientifically. The extinction rate now is an estimated 1,000 times its historical rate, and is increasing continuously. We note that species extinctions have always been part of the evolutionary process, but the dominant causes of species loss today are different from these natural processes. We reaffirm that in our times human activities are the primary cause of species extinction and loss of biodiversity, especially as a result of our competition for land and water, the pollution we generate, and the actions we take that impact the climate and the global environmental in general. The loss of species and of biodiversity is a significant concern because of the intrinsic value of species and biodiversity, the value of potential uses of biodiversity including agro-biodiversity in the future in the changing world ecologies, and most fundamental, because with this loss we limit or lose the mechanisms of future evolution of nature.
3. Collectively the natural history museums, zoological gardens, and botanical gardens reach hundreds of millions of people annually, including youth, and introduce them to the wonders of nature and the need

<sup>10</sup> “Biological Extinction”, Proceedings of the Joint PAS/PASS Working Group, 27 February – 1 March 2017. Scripta Varia 134. Vatican City. <http://www.pas.va/content/accademia/en/publications/scriptavaria/extinction.html>

to preserve them for the sake of those who will come after us. These organizations committed at this conference to enhance their scientific educational mission and their public outreach activities by working more closely together both locally and globally, for example by sharing information, best practices, and exhibitions. The worldwide communities of natural history museums, zoological gardens, and botanical gardens are catalytic and significant allies in the global drive toward species protection and nature preservation. Our common fascination with nature and role as stewards of global nature knowledge and natural heritage leads us to preserve species threatened by human-caused environmental destruction, including climate change and the related loss of species. In these institutions, endangered and extinct species can be studied, so that conservation will have a sound basis. The capacities of these institutions need sustained support and strengthening. They can be drivers of the necessary change, fostering deep reflection and reevaluation of our relation to nature. Their communications and educational activities build public support for appreciating and conserving nature and for the level of international cooperation that alone can make widespread, effective conservation efforts possible.

4. We understand that attempts to build “Noah’s Arks for the 21st century” will not be sufficient to comprehensively limit the loss of species by establishing islands of protection. Fundamental societal change is needed. Reduction of our ecological footprint will be necessary, and consumption patterns must change. Fossil fuel consumption, food waste, land-use change, and deforestation are fundamental drivers of climate change leading to biodiversity losses and species extinctions. These patterns of social behavior and achieve a course correction, as highlighted by the joint Pontifical Academies’ conferences and declarations.<sup>11</sup> Our economic systems need to be redesigned toward circular bio-based economic systems, in which humankind and nature are less in conflict. Science and innovation, sound governance, and incentives for industry and agriculture need to come together to achieve such a sustainable bioeconomy adjusted to local circumstances.
5. Natural history museums and their collections are key to learning about nature and evolution – its past, its present, and its future. These collec-

<sup>11</sup> “Health of People and Planet: Our Responsibility”, PAS-PASS Conference 2017, with a focus on climate change <http://www.pas.va/content/accademia/en/events/2017/health.html>

tions are a unique and truly global scientific infrastructure for science and society as well as the source of much of the information on which effective conservation action can be based. These institutes also attract millions of visitors every year. The overall capacity of these institutions for science, education, as forums of public dialogue and enjoyment, as well their expertise in helping to set environmental policies should be valued and strengthened.

6. Zoological gardens and aquaria at local, regional, and global level provide a chance for people-animal interaction and learning about the beauty of and respect for animals. Zoos also maintain high-level contacts with local, national and regional legislators, global conservation bodies and in situ conservation projects, zoological researchers, educational institutes, and organizations with a shared interest in learning about and preserving biodiversity. The unique ability of zoos and aquaria to save small populations of animals from extinction needs to be employed more extensively. To accomplish this goal, societies and decision-makers need to ensure adequate support to enable them to sustainably perform their vital functions.
7. The living collections of botanical gardens have an educational function for the public, whom they teach about the essential role of plants in enabling our survival and adding beauty and refreshment to our lives. Using these lessons, they teach about the need for conservation, and many of them actively pursue conservation goals. Of the nearly 3,000 botanical gardens in the world, perhaps a quarter also house herbaria and libraries. Using these facilities, botanical gardens conduct research laying the basis for effective conservation activities. Seed banks and tissue culture centers play an important role in plant conservation. For these reasons, botanical gardens, seed banks, and tissue culture centers clearly need sustained long-term support.
8. National parks, protected areas, and other biodiversity-rich areas have an important role to play. Zoological and botanical gardens must work together with them in order to become mutually sustainable. People inhabiting parks and protected areas should be supported and made aware of the importance of conserving biodiversity for future generations. It is essential to include a people-centered approach to conservation, with special attention to indigenous peoples and their knowledge about biological systems and species uses. The alleviation of poverty and the empowerment of all people, especially women and children, is a prerequisite for our conservation efforts to succeed. The huge ineq-

unities within and between nations also need to be addressed effectively to achieve a sustainable global economic system.

9. We support the finding of the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES). We see an important opportunity for international action in the upcoming UN Biodiversity conference 2020 in China. The Convention on Biological Diversity (CBD) is dedicated to promoting sustainable development, with the objectives of conservation of biological diversity (all ecosystems, species, and genetic resources); the sustainable use of the components of biological diversity; and the fair and equitable sharing of the benefits arising out of the use of genetic resources, notably those destined for commercial use. It has not, however, been particularly effective, with about a quarter of the world’s tropical forests having been cleared since the CBD came into effect in 1993, and the very real threat that virtually all such forests may be gone before the end of this century. We urge the CBD’s post-2020 global biodiversity framework to become more ambitious than it has been in the past, particularly in facilitating cooperation between nations while enough time remains to save a major proportion of the world’s existing biodiversity. The kind of education that results from cooperation between the communities of natural history museums, zoological gardens, botanical gardens, and nature conservation specialists has the potential of improving the results that the CBD will be able to achieve in the decades to come.
10. Social justice, combined with a deep, sincere concern for one another, must form the basis for international conservation efforts if they are to succeed. We note the need for science and policy to engage with religious and moral authorities to implement joint strategies aimed at changing the trajectory of humankind. We should not try to make the world a paradise, but we can learn how to take care of it properly. And we must use all our strength to find ways of making the world more human, giving people the possibility to live their lives so that we may share the richness and the resources given to us equably and sustainably. In principle, all major world religions are committed to respecting and preserving nature and can agree on joint actions for this objective. These communities are called upon to explore new synergies for enhanced impact on people’s worldviews and new joint collective actions to address extinction problems. This will include an assessment of the potentials and challenges of building “Noah’s Arks” of our times with new virtual and practical approaches.



- ▶ **II. Lessons and Insights from Natural History Museums' Research and Outreach**





# TOWARDS A 21<sup>ST</sup> CENTURY OPEN AND INTEGRATED NATURAL HISTORY MUSEUM

MAIKE WEISSPFLUG AND JOHANNES C. VOGEL\*

## Abstract

In order to foster a democratic knowledge society, which is able to address the enormous challenges humanity faces, the relationship between science, society, business, and policy needs to be re-configured and reinvented. Democracy is underpinned by science and technology and a more scientifically literate citizenry needs to be fostered to engage in democratic processes and decision making. In order to achieve this, science urgently needs to become more self-reflective and shift substantial resources towards deep public engagement, open science and citizen science.

As they are highly loved and trusted, public facing, excellent science organisations, zoos, botanical gardens and natural history museums need to exercise national and international leadership, act as change agents and pace-makers for open science, society, business and policy. They need to initiate and engage in a constructive dialogue between science and society for the sake of nature and a sustainable future for humans on this planet.

In this article, we explore the rationale for these necessary and long-overdue developments that science needs to undertake.

## Introduction

At first glance, the fact that science is a public matter is taken for granted. Science is public and, even more so, unthinkable without publicity! When we recently discussed at the Museum für Naturkunde Berlin whether a new field of research should be called ‘Open Science’ or ‘Public Science’, some participants shook their heads: Science had always been public, and perhaps the concept of ‘Open Science’ was new at most in the sense of ‘Citizen Science’.

Although a discussion about the public sphere of science sounds plausible, it needs further clarification and differentiation. In the age of digi-

\* Museum für Naturkunde Berlin, Leibniz Institute for Evolution and Biodiversity Research, Invalidenstrasse 43, 10115 Berlin, Germany. Corresponding author: maike.weisspflug@mfn.berlin

tal transformation and an increasing politicization of science, for example around the climate debate, terminology is slipping. It therefore seems to be exactly the right moment to discuss the relationship between science and the public anew.

Our contribution consists of two larger parts. The first part (Sections I to III) deals theoretically with the various relationships between science and the public sphere. In the second part (sections IV to VI) we look at the role of museums as places of 'public' and, particularly important to us, open science. In order to examine the importance of the 'public' for science, we first discuss its two dimensions: public communication (or publishing as an inner-scientific principle) and the opportunities or even social right to participate in science. Both dimensions can be distinguished analytically, but they enter into a new, closer relationship, especially in the context of the debate about an 'open science world'.

We then take a closer look at the debate about open science and show how the principle of inner-scientific communication is expanded and ultimately transformed therein. The relationship between science and the public will be redefined, since science, in view of the great challenges in many (but not all) areas, will again be more strongly oriented towards societal needs. In addition, scientific practices are increasingly being taken up beyond the narrow boundaries of scientific communities, as we show with the example of Citizen Science.

Against this background, we call for embracing the new possibilities of open science. Using natural history museums as examples, we present museums as new places where science and society can meet and discuss the associated practices. Using these examples, we want to show ways in which science can radically open up and transform itself in order to fulfil its role, namely to be a pace-maker and convener for rational truth-finding and a place of co-production of knowledge for a sustainable world and future for humans. For we need a new science that understands itself more strongly as part of social problem-solving processes.

Mission-driven research can, but does not necessarily, contradict the freedom of science. Especially since the threat to freedom today also comes from another side: rational modernity is in the midst of its greatest crisis since the totalitarian catastrophe in the 20th century. By destroying biodiversity, by being at the root of global warming and massive interventions in the Earth's systems, rational modernity also threatens to destroy its own livelihood. If self-preservation is the cornerstone of rational action, we are well on the way to becoming an irrational civilization. Yet it is not too late

to take alternative paths – a science that opens itself further to society and has a strong resonance with the public could be part of the solution.

#### Public communication as a scientific principle

The public, i.e. the accessibility and verifiability of research results, is a prerequisite for a functioning science system. Historically, it was only with modern means of communication, above all the printing press, that the possibility of a cross-location, public and systematic exchange of ideas arose. This made the emergence of modern science possible in the first place. Scientists can thus exchange, question, expand or reject knowledge together. The scientific publication system ensures that knowledge can be tested and recorded, and that it is disseminated and archived. Without this process, without the public communication of research, the immense expansion of scientific knowledge and the immense progress in knowledge would be inconceivable. The fact that scientists communicate publicly guarantees the transparency of the truth-finding processes and, in principle, allows everyone to understand and verify the results once they have been published.

At present, the process of scientific publication generally takes place in a multi-stage process in which publication is preceded by internal quality assurance by experts in the field. In many – albeit still not all – scientific disciplines, the peer-review procedure is regarded as the gold standard for quality assurance. However, this measure alone is increasingly regarded as no longer sufficient for assessing the quality of research. The empirical sciences in particular are experiencing a reproducibility crisis. Increasingly, there is a demand for a stronger opening of the scientific process as a guarantee for the verifiability and traceability of scientific results, for example through the publication of research data as Open Data and the introduction of new standards such as FAIR (findable, accessible, interoperable, re-usable) Data. The debate on Open Science and the expectations of an opening of scientific communication processes will be discussed in more detail later.

First, we turn to the second meaning of the public for science: publishing is not only a functional element in the science system that supports the process of truth-finding, it is also an irreplaceable guarantee for the freedom of science. The right to think, say and publish everything in the name of truth is the indispensable foundation of all free scientific work. Those who claim the freedom of science should not ignore this argument. The internal entanglement of the public sphere and freedom calls for insistence not only on the right of scientists to self-determination (such as

the right to decide on the place of publication), but also on their duty to publish publicly. It is at this point – and the controversial question of how comprehensive the addressed public should be – that the debate on Open Access and Open Science begins.

### **The right to participate in science**

From the outset, modern science was dependent on the response of a broader public and often knew how to make wise use of this public. Spectacular public experiments, such as the invention of the balloon flight and the associated studies on the weather and the structure of the atmosphere, combine the rise of modern science with the emergence of a bourgeois public that took part in the events and defined itself through this practice of public participation.

The right to participate in science found its way into the treaties on the formulation of human rights at an early stage: In the UN Social Covenant, one of the first international human rights conventions binding under international law and, alongside the Universal Declaration of Human Rights, the core of the UN Human Rights Code, participation “in the achievements of scientific progress and its application” (UN Social Covenant, Article 15, Paragraph 1 (b)) is prominently formulated.

Today we take the right to knowledge for granted. It not only includes the right to education, but is also increasingly understood as a comprehensive right to free access to knowledge resources and as the right to participate in the production of social knowledge. Examples such as the free online encyclopedia Wikipedia show that this is not only a noble wish, but that this desire is already acted upon and has become a life practice, albeit not yet comprehensively enforced.

The right to public participation in science is also supported by a democratic argument: In the democratic knowledge society, citizens must be able to inform themselves freely about the state and problems of society. In addition to free access to the media, this also includes access to scientific results. The task of the public and its institutions is to structure this access in such a way that it is possible for everyone without considerable restrictions (e.g. prohibitive fees). The most recent examples from the climate debate show how civil society actors refer to scientific findings to an unprecedented degree. New developments can also be witnessed: the “Fridays for Future” movement is not only drawing heavily on scientific findings from climate research, it also calls on policy-makers to make these findings the basis for climate policy decisions.

The video “The Destruction of the CDU” by the German YouTuber and artist Rezo,<sup>1</sup> addressing the insufficient climate policy of the federal government, is a similar novelty: The video is a political commentary containing innumerable scientific evidence. The fact that civil society involvement – which is also supported by new actors, schoolchildren and social media activists – is approaching science to such an extent and is even using scientific techniques can be seen as a new manifestation of the public character of science.

## Open Science

In the present, we see a shift from the traditional public sphere of science – in its two discussed dimensions – to the demand for open science. The idea of open, i.e. free and public access to scientific publications has been around since the early 2000s. In 2001, the then young Public Library of Science (PLOS) called on all scientists and scholars to publish only in Open Access journals and to review only for them. The “Berlin Declaration” of 2003<sup>2</sup> went one step further and described scientific literature as a cultural heritage and “comprehensive source of human knowledge” to which everyone should have free access.

This can be understood as a normative setting derived from the right to participate in science, but also as a functional argument for reach of scientific knowledge: In the digital and global scientific landscape, granting every member of the scientific community unrestricted access in the competition to find the truth can only be achieved by free and unrestricted access via digital media.

This argument alone would be sufficient to justify Open Access. Following this rationale, the broader public is not the direct addressee, but a direct beneficiary of opening up science in the digital age. However, we should go even further and consider the participatory processes of knowledge generation, which no longer rely solely on scientific peers as actors. Since inter- and transdisciplinary research has long been widely established, the circle of those who should be granted access to the cycles of knowledge is widening. Researchers from other disciplines, actors from

<sup>1</sup> <https://www.youtube.com/watch?v=4Y1lZQsyuSQ>

<sup>2</sup> Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities. 2003. Last accessed on October 16, 2019, at [https://openaccess.mpg.de/67605/berlin\\_declaration\\_engl.pdf](https://openaccess.mpg.de/67605/berlin_declaration_engl.pdf)

civil society, politics, business and ordinary citizens depend on independent access to scientific literature and data to participate in such projects.

The distinction between internal and external scientific communication, which has always been determined by mutual permeability, is thus becoming increasingly blurred. Today, internal scientific communication is less and less limited to one's own scientific peer group, but is increasingly understood inter- and transdisciplinarily. This also has to do with the increase in complexity and the high degree of specialisation of research as well as with a growing awareness that the results of one's own research can also be scientifically interesting for other target groups – for example for a colleague from history or for a transdisciplinary project on urban development. On the other hand, external science communication is often no longer understood solely as the unidirectional communication of scientific results. It seems increasingly sensible to make access to internal scientific communication radically more open, i.e. to make the borders of the scholarly republic, which have long since ceased to coincide with the borders of the disciplines, permeable.

This utopian image of a global knowledge society based on a free flow of knowledge, formulated in the early days of the Internet, is to be understood more as a regulative idea than as a completely attainable goal. Even if science itself requires the principle of public communication, i.e. science cannot do without the public sphere, it is still connected to society in a heteronomous way: Science always remains embedded in social developments, it is in constant mutual exchange with society and is dependent on it in many ways. Above all, risky research (e.g. nuclear research or genetic research) depends on social legitimacy. This tension between society and science seems to intensify regularly in times of political crisis.

An alert observer of such a conflict was the sociologist Robert Merton, who is often referenced today to describe the ideal of an open science. His four buzzwords on science – universalism, communism, unselfishness and organized skepticism – from the text “The Normative Structure of Science” (1942) have found their way into the discourse on Open Science today.<sup>3</sup> It is exciting to take another look at the text in its entirety.

Merton's starting point is the political attacks on science in the USA in the early 1940s. In the 1930s and 1940s, hostility to science arose in the

<sup>3</sup> Merton, R.K. 1942. The Normative Structure of Science. In Merton, R.K. *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago/London: The University of Chicago Press, 267-278.

context of the Second World War. The defining example and frightening picture was the National Socialist banishment of all non-Aryan scientists from Germany and the racial ideological transformation of German science. However, many sentences also apply to today: The attacks on science had shown scientists how dependent they were on a certain social structure. The manifestos and position papers of the time speak for the need of science to reassure itself. Nonetheless, Merton adds, “crisis invites self-appraisal” (p. 287).

A similar self-assurance can be seen today in the “March for Science” movement. First and foremost, it defends science against populist attacks on factual truths such as the denial of climate change. However, the demonstrations frequently conveyed the reductionist image that science itself produces facts and truths, in other words, that science resembles something like the guarantor of truth. This self-presentation is increasingly insufficient in a world in which scientific knowledge, e.g. about global warming and the extinction of species, is gaining ever-greater social significance. It is not enough to insist on the inviolability of science to deal with these problems. What is needed – and this was certainly discussed in the “March for Science” movement – is the assumption of social responsibility by scientists.

The motive of self-reference also runs through other debates about the right relationship between science and the public. In 1985, the Royal Society in London published its report “The Public Understanding of Science” (PUS).<sup>4</sup> The aim was on the one hand to improve the image of science in society, and on the other hand to educate the public more scientifically. In the end, this was intended to lead to a more scientific and rational political decision-making process, which, however, quickly turned out to be ill-founded hope. The “PUS” concept had been based on the so-called deficit model, i.e. the idea of a lack of knowledge on the part of the population, which was to be overcome by ‘more and better’, i.e. one-way and/or top-down communication.

In the following years, and under the influence of the debates on strengthening civil society, a new idea emerged: the deliberative “PEST” model (Public Engagement with Science and Society) called for a contextualisation of science in public debates. The aim here was to make a public

<sup>4</sup> The Royal Society. 1985. *The Public Understanding of Science: Report of a Royal Society ad hoc Group endorsed by the Council of the Royal Society*. The Royal Society, London. Last accessed on October 16, 2019, at [https://royalsociety.org/~media/Royal\\_Society\\_Content/policy/publications/1985/10700.pdf](https://royalsociety.org/~media/Royal_Society_Content/policy/publications/1985/10700.pdf)



assessment of science, for example regarding high-risk technologies such as nuclear power. Public debate formats and the involvement of civil society groups were intended structure the process of public opinion formation.

In contrast to the PUS/PUSH model, this model recognises that there are other forms of knowledge besides scientific expertise that need to be included in public opinion formation. However, it also assumes that the scientific process itself does not have to change. It does allow society to assess research results and to have a certain say where societal actors are concerned. Ultimately, however, the deficit model is reflected here in a weakened form.

Both approaches – PUS/PUSH and PEST – are only partially up-to-date. This applies above all to the deficit model on which the two approaches are based. Current examples of the interaction between science and the public, such as the “Fridays for Future” movement or the Rezo video, show how social actors acquire scientific knowledge independently, competently and actively in order to demand a stronger scientific orientation in politics with regard to the climate crisis and the extinction of species. Basically, this seems like the realization of the PUSH Memorandum with reversed roles. It can be seen as a strong sign of the arrival of a new paradigm: the social co-production of knowledge.

In essence, it is about science understanding itself as a part of society and opening itself permanently to other social actors as communication partners. In this new model, the aim is no longer to teach society scientifically by imparting knowledge from above, but rather to change science itself, to open it up and to be prepared to listen to and learn from society. It would at the same time be an offer to the population to (self-)enlighten, to engage in debate, to participate and to engage in dialogue with science. While PUSH and PEST can be considered to have relatively low success rates compared to the goals they had set for themselves, the chances of success for the co-production of knowledge are greater. While PUSH and PEST wanted to change society, the co-production of knowledge starts with the change of science itself.

The decisive step is no longer to assume a lack of knowledge in the population and the necessity of enlightenment, but to ask how knowledge from society becomes relevant for science, and to take up this knowledge. In many cases, this knowledge may not even be existent, but is being generated by joint activities.

We must, however, make a restriction here. The model of the co-production of knowledge is not a panacea or an end in itself. It is an approach

that can be applied in very different ways to certain issues and problem situations, which today we often refer to as grand societal challenges. Not every discipline and every field of research should be blindly subjected to the new paradigm. Rather, the question should be where science encounters socially pressing questions.

We are of the opinion that it should be part of the freedom of science to determine where this is the case. In many cases, however, scientific institutions are drawn into social and political debates and an experience in dealing with public discourse proves to be an invaluable asset of an institution. Museums can be regarded as the paradigm of such a place of experience.

#### Museums as places for debate

Shortly before Robert Merton's essay on the normative structure of science was published, Margaret Mead wrote a short commentary on "Museums in the Emergency".<sup>5</sup> Three months before the Japanese attack on Pearl Harbor, the anthropologist described an amazing observation: In the midst of the general loss of trust in science, museums had managed to remain trustworthy places of knowledge.

Mead explained this as follows: During the museum visit, people could trust their senses and freely engage with the exhibited material objects, which held a "simple and calm truth" in store. For Mead, museums were therefore places of renewal of trust in science and democracy.

This image is certainly no longer valid today in this unrestricted sense, but a part of it remains true. Museums have become places of debate, where the presentation of objects, their origin and, associated with this, global justice, the handling of the history of violence and museum practices in general are debated. Museums are no longer places of quiet contemplation; today they are places of social debate.

Can they nevertheless be places of trust in science and, if so, in what way? They can only do so because with their collections and objects they harbor a tangible reality, a materiality that brings people together and invites them to enter into a debate about different perspectives on this materiality. In natural history museums, for example, the relationship between man and nature can thus be renegotiated – especially in view of the problematic history of the modern domination and conquest of the world, which becomes tangible in the objects in many ways.

<sup>5</sup> Mead, M. (1941). Museums in the Emergency. *Natural History*, 48, reprinted in 2000 in *Curator: The Museum Journal*, 43: 187. <https://doi.org/10.1111/j.2151-6952.2000.tb01713.x>

In the Museum für Naturkunde Berlin, we experiment with very different forms of communication: We have created the “experimental field” as an open space in the exhibition in which science and visitors can meet and try out different forms of participation in science. For example, every Friday we make the rooms available for exchange between the students of the “Fridays for Future” movement and scientists from various institutes. The museum thus becomes a forum for debate and a place where new ideas can emerge.

With such activities, however, museums move along a fine line between the role of a neutral convener and their own positioning on certain topics. As a place for debate, they have the potential to be a forum in which different perspectives and opinions meet and can be brought into a mutual, fruitful exchange. At the same time, they do not remain neutral in these activities, but already position themselves by choosing the invited actors and the chosen topics. How political can museums be without gambling away social trust? This question will gain importance in the coming years and will demand a great deal of fine-tuned judgement, scientific courage and political wisdom from museums and their leadership.

We have chosen the example of museums – in particular research museums and in particular natural history museums – not only because we know this institution particularly well. In our view, public places, in which very different people can meet, play a major role in the democratic knowledge society. The museum is a fascinating, already quite well-established example, but there are countless other places, each with its own qualities of public sphere: libraries, squares, gardens, bars, even shopping malls are public places where very different people meet by chance and which therefore have a great and sometimes underestimated potential for social knowledge production and participation in science.

New movements, such as Urban Gardening, or new formats of science communication, such as Pint of Science, which bring scientists to such places, are exploring this potential. They are alongside the classic places of enlightened science communication: academies, universities, associations and salons.

### **Citizen Science and the co-production of knowledge**

The model of the place of debate, where scientific and social perspectives meet, still corresponds largely to the deliberative PEST model of science communication, which we have described above as inadequate because it lacks the aspect of mutual knowledge exchange. Natural history

museums, however, are also pioneers of a (perhaps not so) new form of participation in science: citizen science.<sup>6</sup>

In history, the role of laypersons in science has been complex and quite contradictory. In many disciplines, science began as amateur research, for example in biology, taxonomy, geology or astronomy, and in many of these areas the importance of amateur research has not changed to this day. In the field of biodiversity research, for example, the role of amateur researchers should not be underestimated, for example in drawing up the “Red Lists” of threatened species. In 2017, the Entomological Association Krefeld, a civil research association founded in 1905, initiated a broad social debate on the loss of biodiversity internationally with a study on insect mortality.<sup>7</sup> For many years, public researchers had collected data on the distribution of insects in nature reserves in Germany and found a dramatic decline. At that time, no other academic research institution in Europe had such meaningful data at its disposal that could only be obtained through the independence of civic researchers and their persistent and local data collection.

Historically, the importance of amateur researchers can also be seen in the field of botanical and natural history collections: The collections that are now kept in natural history museums and that are still being researched can be largely traced back to amateur natural scientists. With the rise of experimental science in the late 19th century, however, the importance of amateur researchers declined drastically. Laboratories and archives became the determining places of knowledge production through experiments and highly specialized research, in which untrained amateurs could no longer participate independently. Only in a few research fields, such as taxonomy, does the role of amateurs remain significant to this day. In the second half of the twentieth century, however, civil society acquired science in a new way. In particular, the nature conservation movement used scientific methods to detect acid rain and water pollution, for example, and thus build up political pressure. In many cases, these movements were supported by scientists who called themselves “citizen scientists” to draw attention to the social responsibility of science. In some cases, however, a genuine co-pro-

<sup>6</sup> Hecker, S., Haklay, M.E., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (eds.) (2018) *Citizen Science – Innovation in Open Science, Society and Policy*. UCL Press, London. <https://doi.org/10.14324/111.9781787352339>

<sup>7</sup> Hallmann, C.A. et al., (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLoS ONE*, 12: 1–21. <https://doi.org/10.1371/journal.pone.0185809>

duction of knowledge already took place during this phase: One example is the “Act up” movement, which played a major role in research on HIV drugs during the AIDS crisis of the 1980s.

Some lines can be drawn from these movements to what is now called Citizen Science. However, many of today’s Citizen Science projects have a different character. The definition of Citizen Science as civil science, as it is discussed today, did not emerge until the 1990s. Alan Irwin was the first to use the term in 1995<sup>8</sup> to describe the collaboration of citizens and professional researchers in setting research goals. Shortly thereafter, the term was used in the US to describe the participation of amateurs in birdwatching at the Cornell Lab of Ornithology.

The Oxford English Dictionary describes Citizen Science as “scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions”.<sup>9</sup> In the broadest sense, Citizen Science describes the participation of citizens in the production of scientific knowledge itself. However, this participation can take very different forms, which correspond to the normative expectations of Citizen Science to very different degrees.

In the scientific literature on Citizen Science,<sup>10</sup> the different types of Citizen Science are defined by the extent to which citizen scientists are involved in the research process: from pure data collection, interpretation of data, active participation in the formulation of the research question or method, to autonomous implementation or full integration in all phases of the research process. In the Netherlands, for example, the national research agenda has been shaped by a broad, participatory process. Much more often, however, research in the many new Citizen Science projects consists of collecting data for science. This type of participation certainly meets with great public interest: In recent visitor surveys at the Museum für Naturkunde in Berlin, almost a third of respondents said they would like to participate in research activities.

<sup>8</sup> Irwin, A. (1995). *Citizen Science: A Study of People, Expertise and Sustainable Development*. 212 pp. Routledge, Abington/New York.

<sup>9</sup> OED Online (September 2019). “citizen, n. and adj”. Last accessed on October 16, 2019, at [www.oed.com/view/Entry/33513](http://www.oed.com/view/Entry/33513)

<sup>10</sup> For an in-depth discussion on the meaning of *Citizen Science* see: Strasser, B.J. et al., (2019) Citizen Science? Rethinking Science and Public Participation. *Science & Technology Studies*, 32: 52–76. <https://doi.org/10.23987/sts.60425>

Citizen Science's approach is currently receiving strong support from science policy, especially because it holds great promises. These are mainly concerned with better communication of scientific competencies to broad sections of the population and scientific breakthroughs. However, the strength of Citizen Science is not, as is often promised politically, to educate the population as broadly as possible scientifically, nor is it to achieve scientific breakthroughs to the extent promised. With regard to the first question, there is still a lack of empirical studies showing who is actually involved in Citizen Science projects. However, experience from individual projects, such as the British OPAL (Open Air Laboratories) project,<sup>11</sup> shows that it creates considerable effort and costs to involve broad sections of the population in research projects on a sustainable basis. Anyone wishing to use Citizen Science to fulfil this kind of science policy hope must also be prepared to make these investments.

Perhaps the real strength of Citizen Science lies in another area. With this approach, it is possible to overcome the deficit model in the minds of scientists. After all, Citizen Science means bringing other types of knowledge, such as practical knowledge, empirical knowledge or practical knowledge, into contact with scientific knowledge. In this sense, the potential of Citizen Science is far from exhausted.

As justification for the promotion of Citizen Science, the contribution it can potentially make to overcome the great social challenges of our time, in particular climate change and the loss of biological diversity, is repeatedly pointed out. However, this does not only require short-term projects, but also the opportunity for citizens to make a long-term and sustainable scientific commitment. The often short duration of the currently funded Citizen Science projects seems to oppose this for the time being. How Citizen Science can contribute to a structural strengthening of civil society and a knowledge-based democracy, which prerequisites must be fulfilled to achieve these goals and how the activities can be anchored with a long-term perspective in the science system characterised by short-term funding instruments can probably only be determined through practical experience.

However, research funding is not the only future perspective for Citizen Science. More and more projects with a strong political orientation are emerging from civil society, such as Public Lab in the USA, which devel-

<sup>11</sup> <https://www.opalexplorenature.org/aboutopal>

oped a simple and inexpensive technology for aerial photography in the wake of the oil spill in the Gulf of Mexico and thus enabled local residents to collect data on oil pollution in their vicinity. The example of the Krefeld Entomological Association shows that the work of the traditional research associations is also gaining in importance again, even if they suffer from a considerable problem of young talent.

### **A new science for a new world**

It is becoming increasingly clear that we can only tackle the major social issues if broad sections of the public are involved in solving them scientifically and socially and if science becomes a truly public good. Basically, in view of the climate debate, the biodiversity crisis and a multitude of other pressing problems, it is no longer a question of motivating people to deal with these questions and to acquire knowledge about the state of the world. It is about creating new approaches to knowledge and new places of knowledge production. Even though in our contribution we initially only talked about the relationship between science and the public and the involvement of citizens, it is necessary to include other social subsystems such as the economy or the media in these processes in a targeted manner.

Such a reorientation of science may often be paradoxical and difficult, and may confuse the established roles and job profiles. Nevertheless, a new world always calls for a new science, as Alexis de Tocqueville remarked in the face of the American Revolution. We are living in a time of transition and a time that must reinvent itself. In this context, the opening of science and the co-production of knowledge for tomorrow's world represents a new approach that could be worth exploring on a large scale. We are committed to doing so.

## WHAT FUTURE WITHOUT NATURE? HOW NATURAL HISTORY COULD HELP

BRUNO DAVID\*

### Introduction

For several decades, Earth has been facing one of the greatest changes of climate, environments, and life since the Paleozoic. These changes are much more rapid than any other changes, which happened in geological times. They are such that today they induce consequences on our own life. The two central questions are therefore: What kind of relationship do human beings have with the rest of the planet? How can they inhabit the Earth in a more sustainable way?

These questions are central for natural history museums such that they can no longer limit themselves to conventional presentations of nature and its evolution across time in nice galleries. A great natural history museum in the 21st century needs to be committed in the debates; it needs to shed the light of science on complex topics at the intersection of natural history and social sciences. Natural history knowledge and concepts are of great help to address these topics.

### Where museums stand

To contribute to solving environmental questions in their social framework, the Muséum national d'Histoire naturelle in France seeks to strengthen its place and role in the society by being involved in different ways in the public debates. Great temporary exhibitions such as «Us and the others: prejudices and racism» (2017) and «The human rights season» (2018) are of course necessary, but they do not stay long enough and must be complemented by other actions. This is why the Muséum has decided to publish manifestos. Once a year, manifestos are issued to offer scientific facts in a short, efficient format, about a hot topic at the science-society interface. They are not made to dictate anyone's opinion or metaphysical option, but to nurture citizens who would like to take science into account when constructing their own opinion. Their legitimacy comes from the fact that the knowledge about the real world (humans included) that

\* President of the Muséum national d'Histoire naturelle, France.



museums produce and share is scientifically based and can be regarded as a public good. Today, museums in general, and the French Muséum in particular, are facing big challenges that the manifestos could help to tackle.

### **Facing challenges**

The first of them is the environmental challenge. Little by little, protected areas are cut back or downgraded (Golden-Kroner et al., 2019), while the protection of endangered species remains a pure wish or is limited to the commitment of courageous advocates (Abbadie et al., 2017). All recent indicators show that, even more so than climate change, the loss of natural diversity, that is the final extinction of living populations or species (Tilman et al., 2017; Li et al., 2016), the vanishing of entire ecosystems and remarkable natural spaces, is accelerating at a worrisome pace, to the point that the term Anthropocene has been coined to describe this time in history. The trend even touches the human species (with loss of cultural diversity) and is linked primarily to changes we have made to the environment for our survival. It still may be possible to slow the process, but this implies major efforts in education and training. In addition, reversing the trend would require an enabling social context. The questions that are arising today will be asked all the more acutely: What should we protect? Must we protect at all costs? What does it mean to protect species and natural areas when human demand for space and resources is growing? Why should we protect: for selfish economic or survival purposes, for the beauty of nature, for ethical reasons? As pointed out by the International Union for Conservation of Nature (IUCN), the protection of the environment is a prerequisite for economic prosperity and peace. The world must propel energetic and ecological transitions to avoid environmentally and socially risky disequilibria.

Another challenge is the cultural one. At a time in which the American President has decided to withdraw the United States from the Paris Climate Agreement and when sciences are obstinately challenged by obscurantism of every kind, there is no denying it: We have entered a “post-truth” era, with ramifications extending to numerous countries and to the most diverse social categories. This waning of scientific discourse in the public opinion coincides with the emergence of global scepticism. Modern tools used by social networks and media, web-based navigation and publication, and common confusion between the claim for equality in freedom of opinion and equality in legitimacy amplify this (Bronner, 2013; Drummond & Fischhoff, 2017). To halt the spread of relativist approach-

es and to curtail the sometimes tempting albeit unjustified suspicion of science, natural history provides an invaluable framework (Abbadie et al., 2017). We need to get back to more rationality, and to escape a system in which all claims are regarded as equivalent. They are not. If you need bowel surgery, you will not consider the opinion of your surgeon as equivalent to that of your plumber, even if in both cases it is a matter of tubes. We must behave the same way regarding mineralogy, botany, ecology, and all other natural sciences: People have legitimate feelings and opinions toward Nature – and they are free to express them – however, their legitimacy about facts cannot be regarded as equal to facts emerging from these sciences.

Museums need to work toward making the sciences, and natural history in particular, a part of general culture (albeit this has long been the case in many European countries, especially in the North). It is urgent to expand the relatively narrow scope of knowledge and human activities that are considered “cultural”, namely the creative arts, painting, music, theatre, cinema and literature. Indeed, citizens would be reluctant to change their way of life on the sole base of technical claims given by “specialists”. Pedagogy and shared knowledge are crucial to convince people to preserve the future of Earth in a democratic context, and museums are central in this approach.

A third challenge is ethical. Humanity and societies cannot face the environmental challenge without philosophical considerations revisiting the notions of limits, private property, public goods sharing, economism, consumerism and all forces that lead humans to destroy their environment. What could be the ethical framework in which a museum promotes the protection of biodiversity, geodiversity and human diversity? Should we protect biodiversity for short-term ecosystem services? Should we protect biodiversity here and now? Should we protect biodiversity for itself, that is, preserving its evolutionary potential (Sarrazin & Lecomte, 2016; Chan et al., 2016)?

### **Breaking limits**

We will be unable to tackle the environmental challenge without breaking several limits that are consubstantial of what we are: our life span, our size, our ability to move... Natural history makes it possible to break through limits of time, space, and size, to trace back and understand the history of Earth and of life, to inventory biodiversity across the planet from the highest mountains to the depths of the seas, to take into account the smallest forms of life, to analyze the complexity of the ecosystems, to

understand how the living world evolves, and to identify the place of humankind on the planet. This list means that we collectively need to be able to deal with scales that are far beyond those of our current lives. Regarding time, we need to see ahead and foresee long-term trends in our relationship with the physical and living environments. To comprehend fields as different as the epidemiology of infectious diseases, the acclimation of organisms to new conditions, the adaptation of populations to climate change, the impact of genetically modified organisms on wild biodiversity, or the course of evolution, notions of temporality must be brought into the equation. Yet understanding how different timescales are nested within one another is often difficult for the public and for many decision-makers, and even for researchers from other fields. In this sense, natural history can shed light on the historical dimension and complexity of the processes shaping life on Earth.

### **Rooting humans in nature**

To efficiently face both environmental and ethical challenges together, natural history's capital role – and no doubt the most difficult to achieve – is to contribute to raising awareness about humankind's place in nature. The time of a human/nature dualism is over. Natural history roots humans in the natural world and prompts us to think about where we stand within it, rather than against it. That is why the most conservative special interest groups are opposed to it. Natural history explains the biological world through its evolution. The human species is also explained by its natural origins, as a species among others: It comes from another species, it is only 300,000 years old, and surely will disappear.

Humans are, more than ever, implicated in natural dynamics, including those that are underway and that contribute to transforming the planet, up to trying to change the evolution of life, including their own evolution, thereby creating the very conditions that confront them with certain options. It is therefore important to make sure these options find their legitimacy from scenarios in the past, from the current state of the real world and from rational forecasting. Yet this is not just a matter of natural history: This foundation must be established simultaneously with economic and social approaches.

### **Society and science**

As a discipline based on observation, natural history imparts respect for facts and the rejection of dogmatism (Lecointre, 2018). It is a school

of realism and of humility. It impels the “naturalist” to build on validated knowledge that is destined to become a common good. Founded on rationality, it should contribute to restoring the public’s trust in scientific messages, a trust that is indispensable for any democracy that would look ahead to the long-term horizon, and that is especially crucial when it comes to environmental issues. Natural history thereby contributes to cultivating ethical principles that provide guidelines for human conduct at individual and collective levels.

Natural history’s reconquest of the cultural sphere obviously requires lasting support from our institutions, but it is also a matter of mobilizing amateur naturalists, NGOs, citizen science programs, the school system and innovative measures for dissemination. This trend, already underway thanks to the media, remains timid. The dissemination of natural history now requires increasing the usage of modern communications tools and social networks, but also a solid scientific guarantee. Initiatives should aim to reach broad publics through talks and conferences outside of institutions they never attend. Most importantly, we would like to see this scientific culture make it through the doors of the institutions that shape our elite political or business leaders.

More generally, natural history has to provide a critical view on various positions, which are not compatible with science: either in the way they are constructed (e.g. naive reductionism), or because they are based on misconceptions or fakes (e.g. creationism, racism), or because they rely on incompatible philosophical grounds (e.g. essentialism, anthropocentrism), or because they are not compatible with an ethic for the planet (e.g. consumerism, ignorance of limits).

### **An ethic for the planet**

Natural history has the tools and landmarks to promote an ethic for the planet that is oriented toward its long-term preservation (Sarrazin & Lecomte, 2016). In other words, if we have good reasons to preserve a given species or a given environment, natural history has the power to indicate how to preserve its evolutionary potential beyond human needs. To go further, natural history could contribute to elaborate an ethic for the planet that is fully oriented toward preservation of a long-term evolutionary potential of the interrelationships between abiotic constraints, biodiversity and human societies (Sarrazin & Lecomte, 2016; Chan et al., 2016).

Above all, the reasonable and ethically responsible management of quantitative limits attributed to our own species remains the key to a de-

sirable future. It is at this cost that we might eventually be able to restore, over the course of the century, a new, sustainable interaction in which humans, while retaining the benefits of their own production and no doubt increasing them, will be able to reposition themselves as part of nature in a less conquering manner. New pages could then be added to natural history, which could become a “natural civil code”, a non-aggression or at least a compromise pact in a way similar to those resulting from evolutionary stabilizing processes in the numerous species of any ecosystem.

### **To conclude**

Understanding the world and its history to better anticipate its future and discerning what “piece of cake” humans can keep for themselves without seriously undermining their own recourse to the various resources derived from the non-human world, such is the essential role of natural history today. Yet this approach does not imply an isolated, unequivocal vision. It involves ongoing interactions with other forms of human activity that participate in the growth of knowledge and our capacity to forecast the long term: natural history and museums contribute to our grasp of complexity. In this, Europe’s historic role in structuring natural history should extend its pursuit of universality. At several points in the past, natural history has played a major role, contributing to build up the way societies installed themselves in the world around them and evolved. Now, in the early 21st century, it is important to be able to handle scales of time and space that surpass those of our daily lives and to consider how natural history can help the public in an unstable world that is at times shaken by demands laced with sectarianism and intolerance. This will be done with a wide and long-term view allowing for an ethic for the planet based on the preservation of the evolutionary potential of the relationships between the physical-mineral world, biodiversity, and human societies in their diversity.

### **Bibliography**

- Abbadie L., ... Viard F. (2017). *Manifeste du Muséum: quel futur sans nature?* Éditions Reliefs.
- Bronner G. (2013). *La démocratie des crédules*. Presse Universitaire de France.
- Chan K.M.A. ... Turner N.C. (2016). Why protect nature? Rethinking values and the environment. *PNAS* 113(6): 1462-1465. <https://doi.org/10.1073/pnas.1525002113>
- Drummond C. & Fischhoff B. (2017). Individuals with greater science literacy and education have more polarized beliefs on controversial science topics. *PNAS* 114(36): 9587-9592. <https://doi.org/10.1073/pnas.1704882114>
- Golden-Kroner R. ... Mascia MB. (2019). The uncertain future of protected lands and waters. *Science* 364(6443): 881-886.

- <https://doi.org/10.1126/science.aau5525>
- Lecointre G. (2018) Savoirs, opinions, croyances: Une réponse laïque et didactique aux contestations de la science en classe. Belin.
- Li H. ... Zhang Y-P. (2016). Large numbers of vertebrates began rapid population decline in the late 19th century. PNAS 113(49): 14079-14084. <https://doi.org/10.1073/pnas.1616804113>
- Sarrazin F. & Lecomte, J. (2016). Evolution in the Anthropocene. *Science* 351(6276): 922-923. <https://doi.org/10.1126/science.aad6756>
- Tilman D., Clark M., Williams, D.R., Kimmel K., Polasky S. & Packer C. (2017). Future threats to biodiversity and pathways to their prevention. *Nature* 546: 73-81. <https://doi.org/10.1038/nature22900>

## **FOSTERING COMMUNITY ENGAGEMENT WITH NATURE AT THE NATURAL HISTORY MUSEUMS OF LOS ANGELES COUNTY**

GREGORY B. PAULY, BRIAN V. BROWN, AND LORI BETTISON-VARGA\*

### **Introduction**

With expertise in education, outreach, and research, natural history museums are ideally suited to be core sites both for invigorating local communities in understanding, appreciating, and helping study urban nature as well as for building collaborative research networks that can help make urban areas more welcoming for wildlife and for people. Spotlighting ways to boost and sustain Los Angeles's biodiversity, the Natural History Museums of Los Angeles County (NHMLAC) seek to create a new interdisciplinary model for understanding and connecting to urban nature. Through on-site exhibitions, sustainable gardens, programming, bioblitzes, publications, social media, and innovative research programs, our community is engaging with nature while contributing specimens and observations to an extensive collection documenting the region's changing biodiversity. NHMLAC believes that cultivating an understanding of local biodiversity in urban residents may directly lead to improvement in biodiversity outcomes, both locally and in conservation efforts globally. Three museums comprise NHMLAC; the majority of the work described in this paper stems from the research, collections, education, and exhibitions at the Natural History Museum (NHM).

Focusing on urban nature research is not only a successful approach for interacting with the public, but it is also of global conservation relevance. With the human population exceeding 7.6 billion, and with the majority of people now living in urban areas, documenting and mitigating the impacts of urbanization are critical for urban conservation, planning, and land management. Here, we outline our education, exhibition, outreach, and research efforts focused on urban nature, and how these have 1) established NHM as a core site invigorating the community around urban nature

\* Natural History Museums of Los Angeles County, Los Angeles, California, 90007, USA; Corresponding author is Lori Bettison-Varga ([lbv@nhm.org](mailto:lbv@nhm.org))

and 2) promoted the development of research networks and collaborative partnerships that apply urban biodiversity data to urban land management and planning issues.

Note that throughout this overview, we use the phrase “community science” as a synonym for “citizen science”. Community science is an essential approach in our urban nature research and therefore a significant component of our outreach. However, we find the phrase “citizen science” to be problematic. Proponents of this phrase often emphasize that we are all part of a global citizenry that can contribute to biodiversity discovery, research, and conservation. Nevertheless, the word “citizen” can be polarizing and even alienating to some, especially those who may not be naturalized citizens of a given country where a research project is being conducted. Thus, at NHMLAC we use the term “community science”, in hopes that it is more inclusive when reaching out to and serving a diverse audience.

### **From Natural History to Living Nature**

To create a new interdisciplinary model for understanding and connecting to urban nature, NHM developed exhibitions to get local residents excited about the incredibly diverse biota that can be found all around them, all the time. In the terminology of the Museum, the goal of these efforts was to get people “to put their nature eyes on”. The hope was to make people aware that there is no magic line where nature stops and city begins, and that interesting biodiversity discoveries can be made anywhere, even in the most urban parts of a city.

At NHM, the diorama halls are among the finest in the world, and beloved by visitors of all ages. Yet, audiences seek experiences that move beyond passive observation to active engagement, extending the relevance of museum collections and research. The move from “viewing to doing” inspired NHM scientists and exhibition developers to create the Nature Lab, a 600-square meter permanent hub of investigation where visitors of all ages can participate in real science research, learn scientific methods, and engage in hands-on activities that build their observation skills. The Nature Lab features live animals, touchable specimens, community science projects and discoveries, and multimedia. The Nature Lab transcends traditional natural history exhibitions by focusing on a new relevance and connection to living nature. This exhibition invites visitors to get up close and personal with live animals, to meet real scientists doing real science, and to interact with observations generated daily by community scientists through re-



al-time images submitted through iNaturalist, a free community science app and platform for reporting personal observations of any species.<sup>1</sup> The Nature Lab presents a unique new approach to the interpretation of urban ecosystems and the creatures that live in our cities and communities, offering a detailed look into the interesting lifestyles, adaptations, and challenges facing urban wildlife. This interactive exhibition also creates a bridge between the Museum's indoor research and collections, and its new outdoor space: the Nature Gardens.

NHM's 1.5-hectare nature and teaching garden outside the doors of the Nature Lab extends the museum experience outdoors to an exploration of living nature. Inside this urban wilderness, visitors spot birds and butterflies, learn to observe and track species with our scientists, engage in gardening workshops and nature walks with our educators, and poke around a new civic green space that is all too rare in Los Angeles. It is a purposely layered experience to attract all ages, with more than 600 different plants, a pond, an edible garden, a living wall constructed of rocks and plantings that attract wildlife, a water feature representing Los Angeles's water system, a pollinator garden, and ground trumpets that tap into tree roots to hear the sounds a tree makes. Interpretive signs throughout the Nature Gardens provide visitors with seasonal information; programming for school visits and the public takes place in the edible garden; and a get dirty zone allows kids to learn through play about compost and plants. The Nature Gardens also serve as a research site for Museum scientists studying urban biodiversity. For example, a Malaise trap and weather station are installed in the Gardens to monitor insect diversity as part of the Biodiversity Science: City and Nature (BioSCAN) project discussed below. A bat detector is also installed near the Gardens' pond, as part of a larger urban survey of the region's bat diversity. Together, the Nature Lab and Nature Gardens provide the backdrop for an annual weekend-long Nature Festival, with raptor flight demonstrations, conversations with scientists and nature experts, performances, and hands-on activities.

These two public exhibits and their associated interpretive activities all focus on the key message that nature is all around us at all times. Angelenos do not need to leave the city to experience nature; these exhibits highlight that they can observe nature anywhere, including in their own neighborhoods.

<sup>1</sup> <https://www.inaturalist.org/>

## The Urban Nature Research Center and Community Science

During the process of conceptualizing the Nature Lab and Nature Gardens, scientists at NHM realized the potential for extending their research to focus on the local, urbanized environment. The Museum's collections provide evidence of where species were found in the past, and if these historical records could be compared to modern-day species occurrence records, then the researchers could assess how species are responding to urbanization. Critically, such a research effort would increase the relevance of the Museum's historical collections, especially for members of the public who rarely experience the treasure trove of objects maintained in museum research collections.

Los Angeles is also a major hub of transportation and industry. Many people and goods move through the region daily, and, unfortunately, many non-native plants and animals are introduced as well. Los Angeles's Mediterranean climate, in combination with the high levels of water available in urban areas, makes the area agreeable to many species of plants and animals, allowing them to survive and thrive in their new home. Being able to document and track the spread of these introduced species could have important conservation, ecological, and economic impacts. For both the above research efforts (i.e., studying responses to urbanization and tracking introduced species), the key was to identify survey methods that could efficiently generate species occurrence data in a heavily urbanized environment.

Los Angeles spans an enormous geographical region with heavily urbanized areas that are mostly private property. Scientists could not adequately survey the region on their own and most traditional biodiversity survey methods are not effective when the habitat to survey is a patchwork of private properties. The NHM team realized that developing an accurate picture of which species are living in L.A. would require partnering with the region's residents.

With the realization that community science is the most effective way to survey urban biodiversity (Spear *et al.*, 2017), several community science projects were launched and a staff position was created to manage community science efforts. With growth in the interest and number of community science projects promoted by NHM researchers, this single staff position was expanded into a Community Science Office, which, as of 2019, includes four full-time and two part-time staff members. In 2015, the Urban Nature Research Center (UNRC) was formalized, resulting in the first integrative research center in the United States dedicated to

urban biodiversity. UNRC scientists use the entire city of Los Angeles to extend scientific research and investigation beyond the perimeters of the Museum's 1.5 hectares of Nature Gardens habitat (Parker *et al.*, 2019). This integrative center spanned the traditional taxonomic sections of a natural history museum, uniting a diverse set of scientists under the common goal of understanding urban biodiversity. The UNRC began with two curators and a postdoctoral researcher as the lead researchers and has now grown to include five curators, two postdoctoral researchers, and two full-time and two part-time staff scientists.

This focus on urban biodiversity not only resonates with Museum visitors and Southern California residents, but it has also proven to be an incredibly productive research focus. From 2013 to 2019, UNRC scientists published 29 peer-reviewed manuscripts as well as six popular press articles. Eight of the peer-reviewed publications were authored or co-authored with community scientists (e.g., Bernstein and Bernstein, 2013; Pauly *et al.*, 2015; Pauly and Borthwick, 2015; Pauly and Gavit, 2019; Vendetti *et al.*, 2018a,b). These publications focus on diverse topics including discoveries of species new to science (Hartop *et al.*, 2015; 2016a,b) and of non-native species never previously documented in the area (Larson *et al.*, 2015; Pauly and Borthwick, 2015; Pauly *et al.*, 2015a,b; Pauly and Gavit, 2019; Vendetti *et al.*, 2018a,b).

The following are examples of UNRC research projects that engage community scientists in the collection of data:

*BioSCAN (Biodiversity Science: City and Nature)*.—BioSCAN is a large-scale survey of backyard insect diversity, which has already yielded 43 species new to science and several improbable new species distributions. Community scientists allow a weather station and a Malaise trap, a tent-like trap that catches insects, to be installed in their yards for up to one year; these site hosts monitor this equipment and help change out collecting bottles. The resulting insect samples are sorted by volunteers, undergraduate students, and NHM scientists, and much of this sorting takes place in front of the public inside the Nature Lab. Since its inception in 2015, the project has resulted in training more than 80 work-study students from the University of Southern California and more than 30 volunteers, all of whom participate in sorting trap samples to more manageable taxonomic units. These samples are then provided to the BioSCAN scientists who sort them further, including to species for select taxa. In addition to the discovery of species new to science, BioSCAN scientists have also examined seasonal trends in insect abundance (Brown and Hartop, 2016) and

documented major range extensions, potentially due to the introduction of non-native species (Grimaldi *et al.*, 2015). By combining the insect data with weather data and GIS analyses, the BioSCAN team is also examining impacts of urbanization on the insect fauna (Adams *et al.*, in review, McGlynn *et al.*, 2019). As of summer 2019, BioSCAN has been run for four rounds, with about 80 sites surveyed.

*GeckoWatch*.—This project was inspired by the early success of the RASCals project (see below) at documenting non-native geckos in Southern California. Multiple species of house and wall geckos (*Hemidactylus* and *Tarentola*, respectively) have been introduced to the United States, but these usually show up in residential neighborhoods or industrial districts where professional biologists are unlikely to quickly detect the new arrivals. To improve detection times, GeckoWatch was created to more effectively track the expanding range of non-native geckos across the United States, with a special focus on the Mediterranean house gecko, *Hemidactylus turcicus*, which is a research focus for NHM Herpetologist G. B. Pauly and GeckoWatch co-creator Dr. Robert Espinoza of California State University, Northridge.<sup>2</sup> The project has resulted in more than 750 observations from more than 250 contributors.

*L.A. Spider Survey*.—This project was one of the Museum's early forays into using community science to study urban biodiversity. Since 2002, more than 1,500 participants have provided observations and specimens that present a detailed and profound glimpse into how L.A.'s spider fauna has changed over the past 100 years and how it continues to change today. More than 5,000 spiders, representing 217 species and 119 genera in 36 families, have been added to the Museum's collection by community scientists. Impressively, this project has largely been overseen by a dedicated and talented volunteer, who has led the identification and preservation of the spider specimens. Further, this volunteer and UNRC scientists visit the BioSCAN site hosts several times a year and conduct spider surveys of these sites. An important early discovery for the Spider Survey was the first occurrence of the brown widow spider (*Latrodectus geometricus*) in Los Angeles, which was recorded in 2002; this invasive species has expanded rapidly across the Los Angeles Basin and appears to be displacing the indigenous black widow spider.

*RASCals (Reptiles and Amphibians of Southern California)*.—RASCals was designed to improve knowledge of native and non-native reptiles and

<sup>2</sup> <https://www.inaturalist.org/projects/geckowatch>

amphibians across Southern California.<sup>3</sup> This project is housed on the iNaturalist platform and was specifically created 1) to generate modern-day species occurrence records that could be compared to historical museum records to assess how species have responded to urbanization and 2) to document and track non-native species. Since its inception in June 2013, RASCals has received more than 48,000 observations from more than 6,000 community scientists. Community science observations include five new state records and 21 new county records documenting the introduction and spread of non-native species in California. These discoveries have resulted in six peer-reviewed publications authored or co-authored by community scientists (e.g., Pauly and Borthwick, 2015; Pauly *et al.*, 2015; Pauly and Gavit, 2019).

*SLIME (Snails and Slugs Living in Metropolitan Environments).*—NHM’s collection of land snails includes thousands of specimens from locations throughout the Los Angeles Basin and spans the past 100 years, but very little is known about this mollusk diversity today. SLIME was created to fill in this data gap.<sup>4</sup> Like RASCals, SLIME was developed in part to generate modern-day species occurrence records from urban areas, with the recognition that this approach would likely dramatically improve detection times for non-native snails and slugs introduced to Southern California. Since August 2015, more than 2,000 community scientists have contributed to this project housed on the iNaturalist platform, yielding more than 14,000 observations. These observations include three new state records and seven new county records, with two publications co-authored with community scientists to date (Vendetti *et al.*, 2018a,b). Of special note is that Vendetti *et al.* (2018a) used a novel approach to recognizing the contributions of community scientists, listing “citizen science participants in SLIME and BioSCAN” as co-authors in the author by-line of the resulting manuscript. UNRC scientists have termed this approach “group co-authorship” and have modeled it after the now commonplace idea of “group authorships”. UNRC scientists are promoting this approach as an important new way of recognizing community scientist contributions (Ward-Fear *et al.*, in press).

*Southern California Squirrel Survey.*—Like RASCals and SLIME, the Southern California Squirrel Survey was set up on the iNaturalist platform to document squirrel species across the region, and especially to document the expanding range of the non-native eastern fox squirrel (*Sciurus niger*)

<sup>3</sup> <https://www.inaturalist.org/projects/rascals>

<sup>4</sup> <https://www.inaturalist.org/projects/slime>

and the declining range of the native western grey squirrel (*Sciurus griseus*). Since September 2013, the project has amassed more than 5,500 observations from over 1,000 contributors.<sup>5</sup>

*The SuperProject.*—Although community science has proven exceptionally effective at generating urban species occurrence records (Spear *et al.*, 2017), there are regions across Los Angeles that have lower participation resulting in little biodiversity data for some neighborhoods. In 2016, UNRC scientists developed the SuperProject to recruit and train community scientists from specific geographic areas that are of interest for biodiversity studies. These participants then conduct surveys of core sites (typically their backyards or a common area of their apartment complex) as well as surveys of their own neighborhoods, contributing photo-vouchered species occurrence records to iNaturalist as well as submitting online survey forms describing the ecological conditions of their neighborhoods.<sup>6</sup> The SuperProject participants contribute records of diverse organisms living in the urban environment, and when taxonomically appropriate, they also contribute records to RASCals, SLIME, and the Southern California Squirrel Survey. These surveys take place for one full year. The SuperProject has been especially useful at generating species occurrence records used for large-scale urban biodiversity studies, such as the Biodiversity Analysis in Los Angeles (BAILA) initiative discussed below. In SuperProject 3, which was conducted September 2018 through August 2019, 97 “site hosts” contributed more than 26,000 urban species occurrence records from southern Los Angeles, a heavily urbanized region for which there was previously very little biodiversity data available.

A key ingredient for maintaining high levels of participation in the SuperProject is providing participants with unique resources and opportunities. Over the course of the year, SuperProject participants can attend four bioblitz events for which they have priority registration as well as a mid-year and end-of-year party. Participants can also interact with each other and NHM staff on a SuperProject Facebook page, and they receive a digital newsletter twice a month, highlighting exciting discoveries and informing them of interesting nature to watch for in the coming weeks (e.g., fungi, snails, slugs, and salamanders in the winter months and hatching lizards in late summer).

<sup>5</sup> <https://www.inaturalist.org/projects/southern-california-squirrel-survey>

<sup>6</sup> <https://www.inaturalist.org/projects/superproject-3>

## Increasing Urban Nature and Community Science Outreach

While people can certainly learn about urban nature and community science while visiting the exhibitions at NHM, we believe it is also important to meet people in their own neighborhoods, going to them, instead of asking them to always come to the Museum. Most of the approaches discussed in this section are used to reach people in their own neighborhoods. These efforts also provide opportunities to recruit new community scientists to participate in the various community science projects highlighted above.

*Bioblitzes and Community Science Meet-Ups.*—The Community Science Office coordinates 6–12 bioblitzes and community science meet-ups each year. Scientists from the UNRC frequently provide biological expertise at these events. Events sometimes include training sessions in which attendees can learn how to use the iNaturalist app before heading off to make observations. At other events, the focus is on building community amongst existing iNaturalist users, and attendees participate in a bioblitz, trying to document as many species as possible in a fixed amount of time. Frequently, these events are conducted in partnership with local parks that are interested in the species occurrence records resulting from the bioblitz or meet-up. Here again, the Museum’s focus on urban nature is helping to develop partnerships with parks and land-management organizations throughout the region.

*City Nature Challenge.*—In 2016, NHMLAC and the California Academy of Sciences in San Francisco co-founded the City Nature Challenge. This program, which originally was a friendly competition between two rival cities, was launched for the first ever Citizen Science Day in order to draw attention to urban nature. Encouraging residents of these large urban regions to “put their nature eyes on” resulted in more than 1,000 participants making nearly 22,000 observations of approximately 2,800 species, with several noteworthy records. Enthusiasm for the project spread rapidly and additional cities began participating, with 16 US cities participating in 2017 and 64 cities around the world in 2018. The City Nature Challenge in 2019 engaged residents and visitors of 159 cities around the world. More than 35,000 participants logged more than 960,000 observations of more than 31,000 species during the four-day competition period ([citynaturechallenge.org](http://citynaturechallenge.org)). Since its inception, the City Nature Challenge sets new activity records each year on the iNaturalist platform. Critically, the media and outreach associated with this event inspires new community scientists to join the iNaturalist platform, making more observations after the Challenge has ended.

*Partnerships with other County Departments.*—Since 2017, the Community Science Office, in collaboration with the NHM’s Education Division, has been involved in supporting curriculum writing and training staff of the Los Angeles County Department of Parks and Recreation (LADPR) for a new summer camp program termed the ESTEAM (environment, science, technology, engineering, arts, and mathematics) Summer Camp Program. ESTEAM builds upon the well-known concepts of STEM and STEAM by adding a significant focus on the environment. The curriculum for the ESTEAM Camps was co-created through an NHMLAC/LADPR partnership, in which the goal was to integrate community science curricula into diverse communities through programming. NHM staff trained camp staff in the use of iNaturalist as well as other nature activities to connect youth to urban nature. The community science team visits many of the camps and also participates in the County’s Parks After Dark program, which focuses on building a sense of community around residents’ local parks. The ESTEAM Summer Camp Program began with eight county parks and then expanded to 17 parks. The NHMLAC/LADPR collaboration also expanded to include after school programs at 46 parks in the month of April focused on the City Nature Challenge. These efforts help to raise awareness about urban nature as well as to recruit new community scientists who might then join us in studying urban biodiversity.

In 2018, the Community Science Office began a new partnership by collaborating with the Los Angeles County Libraries to pilot community science tool kits available for check out. The community science kits were designed to provide children and parents a resource to help them explore nature in and around Los Angeles. The prototype kits include an instructional guide, a journal, and specific tools to encourage outdoor exploration and nature investigation. People with library cards check the kits out from librarians and may take them home, to local parks, to their school, etc. Checkout period is two weeks. Librarians review the kits at checkout and upon return to verify all materials are returned and in good condition. Kit testing has been conducted at six libraries (4–6 weeks per location; 5 kits at each library) over the course of 1.5 years. Kits are currently getting ready to be museum-branded and then launched on a permanent basis at five libraries across the county.

*Wild LA: A New Model for Urban Nature Guidebooks.*—Because natural history museums have personnel with expertise in local biodiversity, informal science education, and communication, they have many of the key ingredients for producing nature guides. In spring 2019, *Wild LA: Explore*



*the Amazing Nature in and Around Los Angeles* was released. The book was co-authored by Lila Higgins, Sr. Manager of Community Science, and Greg Pauly, Co-Director of the UNRC and Curator of Herpetology, as well as two professional nature writers. Further, many of the Museum's researchers assisted by providing information and then reviewing select parts of the manuscript to ensure scientific accuracy across diverse topics. *Wild LA* presents Los Angeles's natural history, while serving as a field guide and trip planner for local nature excursions. *Wild LA* introduces readers to Los Angeles nature in three parts: 1) short, fun chapters introducing readers to the local ecology; 2) 101 species accounts; and 3) 25 recommended excursions spread across the region where people can see the species and themes presented in the book. The book is intended to be very accessible, with fun facts and callouts on every page, in addition to numerous photographs and drawings.

*Media, Media, Media.*—Meeting people in their own neighborhoods can also be done through social and traditional media. Social media platforms (e.g., Facebook and Instagram) can be used to share exciting urban nature observations as well as to announce research efforts that might be of particular interest at that time of year. Many museums also have member publications in which community scientists, community science events, and research discoveries can be shared. At NHMLAC, we routinely feature community scientists and their discoveries in our member magazine, the *Naturalist*, which reaches more than 30,000 households. Traditional media can also be used to reach a broad audience, providing opportunities to highlight both community science efforts and also to advertise for the museum. Further, a standard “best practice” in the community science field is to ensure that community scientists learn of the results and publications arising from their contributions. Strategic media can simultaneously inform the public of interesting urban nature research as well as inform past participants of the research they have helped facilitate.

*Demonstration Tables and Pop-up Exhibits.*—Much of this section has focused on outreach efforts directed toward people in the community. However, it is also critical to provide new opportunities for regular museum patrons to have new experiences at the museum. Urban nature discoveries are especially well-suited for short-term exhibits because members of the public can easily relate to discoveries from the local area, made by local residents. For example, in 2017, scientists and exhibit developers from NHM partnered with scientists from the Santa Monica Mountains National Recreation Area to develop a temporary exhibit focused on the

mountain lions that manage to survive – and in some cases to thrive – in the mountains immediately to the north of the Los Angeles Basin. Los Angeles and Mumbai, India are the only two major cities in the world with populations of big cats inside the city, and the Museum’s goal was to highlight this interesting nature fact. This exhibit also showcased P-22, an internationally recognized male mountain lion inhabiting Griffith Park, where he hunts deer and other mammals adjacent to the famous Hollywood sign. The Demonstration Table inside the Nature Lab also provides a unique opportunity for outreach; undergraduates and volunteers staff this table during the Museum’s busiest hours. They sort insects for the BioSCAN project, discuss their work – including the latest discoveries – with the public, and also promote other community science projects of potential interest to the visitor.

### **Community Science Establishes NHM as a Hub for Urban Biodiversity Research**

Urbanization has numerous ecological impacts, and among the most consequential are the loss of habitat and introduction of invasive species, which both have serious consequences on native biodiversity. Although urbanization presents one of the greatest global threats to biodiversity, urban biodiversity is markedly understudied. In large part, this is because it is so challenging for biodiversity scientists to work in urban areas. Biological survey techniques used for decades in diverse ecosystems around the world often cannot be used in urban areas where researchers find themselves on a new piece of private property every dozen or so paces. Research methods using community science get around this problem by partnering with the community members who do have the ability, access, and local knowledge to gather urban species occurrence records. With their diverse expertise in education, outreach, and research, natural history museums can develop effective community science projects allowing them to gather tremendous amounts of urban biodiversity data. As a result, researchers at local universities, nonprofits, and governmental agencies often seek to partner with museums in hopes that productive collaborations can be developed to address specific research and management questions.

As one example, consider the RASCals project, which has resulted in its lead scientist, Greg Pauly, developing numerous collaborations with other researchers in California. Dr. Amanda Zellmer of Occidental College and Pauly are collaborating to use urban salamander records to understand the distribution of two species across the Los Angeles region. Records are also

used to develop strategic field sampling protocols for a landscape genomics project examining the impacts of urbanization on gene flow. Similarly, Dr. Jeanne Robertson and master's student Sarah Wenner of California State University, Northridge (CSUN), are collaborating with Pauly to examine the current distribution and genetic connectivity among populations of the declining Blainville's Horned Lizard. Robertson and Dr. Robert Espinoza, also of CSUN, are using community science records to understand the distribution of non-native geckos. Further, biologists from the California Department of Fish and Wildlife coordinate with Pauly to document the introduction of several restricted species, many of which are arriving in California through the nursery plant trade and are only being detected in the yards of local homeowners who then report their discoveries via iNaturalist or directly to the Museum. Most importantly, the above examples are just for one project and include some but not all such collaborations; similar collaborations could be enumerated for SLIME, BioSCAN, and the various other projects. While NHMLAC has been an important resource for biological expertise since its inception in 1913, the focus on urban nature has greatly increased the number and diversity of collaborations.

The shared interest in urban biodiversity led to an especially productive collaboration between NHMLAC and The Nature Conservancy (hereafter "the Conservancy"). As stated in Parker *et al.* (2019; p. 16),

*the Museum's scientists brought expertise and experience conducting research and leading community science projects that are providing new insights into the distribution and abundance of native and non-native species across the metropolitan area... (while)... the Conservancy's scientists brought experience and expertise in conservation planning and practice... along with a history of working with a variety of stakeholders to achieve conservation successes.*

Scientists from the two institutions launched a collaborative effort termed Biodiversity Analysis in Los Angeles (BAILA) that used nearly 60,000 species occurrence records from more than 10,000 community scientists to map species across the Los Angeles region. Results of this effort are now published in the peer-reviewed literature (Li *et al.*, 2019) and as a separate report that provides additional information about the process (Parker *et al.*, 2019).

Is there value to the community science efforts beyond collecting observations for our scientific programs? Ballard *et al.* (2017) analyzed 44 community science programs across three museums to assess whether and how community science efforts contribute to conservation-relevant outcomes. They found evidence that these programs support conservation

both directly, through site and species management, and indirectly through research, education, and policy impacts. This study has implications for understanding the role natural history museums can play in maximizing the socio-ecological impacts of community science, including bringing community science to new audiences, mobilizing volunteers to collect and analyze data to study species invasions and impacts of global changes, and conducting locally-relevant research in urban systems. This effort also highlights that natural history museums engaging in community science work can develop collaborations focused specifically on biodiversity research as well as collaborations evaluating community science as a research method as done in the Ballard et al. (2017) study.

## Bibliography

- Adams, B.J., E. Li, C.A. Bahlai, E.K. Meineke, T.P. McGlynn, and B.V. Brown. *In review*. Local and landscape scale variables shape insect diversity in an urban biodiversity hotspot. Ecological Applications.
- Ballard, H.L., L.D. Robinson, A.N. Young, G.B. Pauly, L.M. Higgins, R.F. Johnson, and J.C. Tweddle. 2016. Contributions to conservation outcomes by natural history museum-led citizen science: Examining evidence and next steps. *Biological Conservation* 208:87-97. <https://doi.org/10.1016/j.biocon.2016.08.040>
- Bernstein, W.L., and R.W. Bernstein. 2013. Geographic distribution. *Hemidactylus turcius* (Mediterranean Gecko). *Herpetological Review* 44(3):474.
- Brown, B.V., and E.A. Hartop. 2016. Big data from tiny flies: patterns revealed from over 42,000 phorid flies (Insecta: Diptera: Phoridae) collected over one year in Los Angeles, California, USA. *Urban Ecosystems* 20(3):521-534. <https://doi.org/10.1007/s11252-016-0612-7>
- Grimaldi, D., P.S. Ginsberg, L. Thayer, S. McEvey, M. Hauser, M. Turelli and B. Brown. 2015. Strange little flies in the big city: Exotic flower-breeding Drosophilidae (Diptera) in Urban Los Angeles. *PLoS ONE* 10(4):e0122575. <https://doi.org/10.1371/journal.pone.0122575>
- Hartop, E.A., B.V. Brown, and R.H.L. Disney. 2015. Opportunity in our ignorance: Urban biodiversity study reveals 30 new species and one new Nearctic record for *Megaselia* (Diptera: Phoridae) in Los Angeles (California, USA). *Zootaxa* 3941:451-484. <http://dx.doi.org/10.11646/zootaxa.3941.4.1>
- Hartop, E.A., B.V. Brown, and R.H.L. Disney. 2016a. Flies from L.A., The Sequel: A further twelve new species of *Megaselia* (Diptera: Phoridae) from the BioSCAN Project in Los Angeles (California, USA). *Biodiversity Data Journal* 4:e7756. <https://doi.org/10.3897/BDJ.4.e7756>
- Hartop, E.A., M.A. Wong, and C.S. Eisman. 2016b. A new species of *Megaselia* Rondani (Diptera: Phoridae) from the BioSCAN Project in Los Angeles, California, with clarification of confused type series for two other species. *Proceedings of the Entomological Society of Washington* 118(1):93-100. <https://doi.org/10.4289/0013-8797.118.1.93>
- Larson, G.C., C. Huntley, G.B. Pauly, T. Wolfmeyer, B. Singh, and R.E. Espinoza. 2015. Geographic distribution. *Hemidactylus turcius* (Mediterranean Gecko). *Herpetological Review* 46:59.
- Li, E., S.S. Parker, G.B. Pauly, J.M. Randall, B.V. Brown, and B.C. Cohen. 2019. An

- urban biodiversity assessment framework that combines an urban habitat classification scheme and citizen science data. *Frontiers in Ecology and Evolution* 7:277. <https://doi.org/10.3389/fevo.2019.00277>
- McGlynn, T.P., E.K. Meineke, C.A. Bahlai, E. Li, E.A. Hartop, B.J. Adams, and B.V. Brown. 2019. Temperature accounts for the biodiversity of a hyperdiverse group of insects in urban Los Angeles. *Proceeding of the Royal Society, B* 286:20191818 <https://doi.org/10.1098/rspb.2019.1818>
- Parker, S.S., J.M. Randall, G.B. Pauly, E. Li, B.V. Brown, and B.C. Cohen. 2019. Biodiversity Analysis in Los Angeles (BAILA). Co-Published by The Nature Conservancy and the Natural History Museum of Los Angeles County. Available from <https://www.scienceforconservation.org/products/BAILAreport>
- Pauly, G.B., and D.B. Borthwick. 2015. Geographic distribution. *Anolis carolinensis* (Green Anole). *Herpetological Review* 46:567.
- Pauly, G.B., G.S. Yoshida, and R. Worrell. 2015a. Geographic distribution. *Hemidactylus garnotii* (Indo-Pacific Gecko). *Herpetological Review* 46:569.
- Pauly, G.B., A. Wells, M.H. Espinoza, T.A. Wake, R.E. Espinoza. 2015b. Geographic distribution. *Hemidactylus turcicus* (Mediterranean Gecko). *Herpetological Review* 46:59.
- Pauly, G.B., and P.D. Gavit. 2019. Geographic distribution. *Trachylepis quinque-taeniata* (African Five-lined Skink). *Herpetological Review* 50:103-104.
- Spear, D.M., G.B. Pauly, and K. Kaiser. 2017. Citizen science as a tool for augmenting museum collection data from urban areas. *Frontiers in Ecology and Evolution* 5:86. <https://doi.org/10.3389/fevo.2017.00086>
- Vendetti, J.E., C. Lee, and P. LaFollette, and citizen science participants in SLIME and BioSCAN. 2018a. Five new records of introduced terrestrial gastropods in Southern California discovered by Citizen Science. *American Malacological Bulletin* 36(2): 232-248. <https://doi.org/10.4003/006.036.0204>
- Vendetti, J.E., E. Burnett, L. Carlton, A.T. Curran, C. Lee, R. Matsumoto, R. McDonnell, I. Reich, and O. Willadsen. 2018b. The introduced terrestrial slugs *Ambigolimax nyctelius* (Bourguignat, 1861) and *Ambigolimax valentianus* (Férussac, 1821) (Gastropoda: Limacidae) in California, with a discussion of taxonomy, systematics, and discovery by citizen science. *Journal of Natural History* 53(25-26):1607-1632. <https://doi.org/10.1080/00222933.2018.1536230>
- Ward-Fear, G., G.B. Pauly, J.E. Vendetti, and R. Shine. *In press*. Authorship protocols must change to credit citizen scientists. *Trends in Ecology and Evolution*.

## 4 HISTORY IN ACTION: THE ROLE OF NATURAL HISTORY MUSEUMS IN CONSERVATION

RICHARD W. LARIVIERE\*

Leading our audiences to action is a crucial part of natural history museums' obligation. We may have been created in previous centuries with very different roles, but we are no longer cabinets of curiosities. It is true that the world's great natural history museums are repositories of the history of life on earth, and that the evidence held in our collections is unique and irreplaceable. It is also true that we have an obligation to provide guidance and leadership in turning knowledge into action. Our collections contain the answers to scientific questions as yet unasked and even unimagined. The technology of scientific inquiry will continue to change at an astonishing rate. As it does, the value of our collections will correspondingly increase. Thus, the moral obligation to preserve and curate our collections expands daily. However, our moral obligation does not stop there.

In a recent conversation with a top scientist at the Field Museum, he objected to a statement that was proposed for one of our documents that said, "The Field Museum offers science as a force for good". His position was that science is neither "good" nor "bad". It simply is. Science describes what is. It may be accurate or inaccurate in its description, but it is not good or bad. He is right. Yet, what one does with the discoveries of science can indeed be good or bad. To be sure, the good and the bad consequences may be just as complicated and nuanced as the science that underlies the consequences. One need only look at the use of antibiotics and fungicides in the agricultural industry to see both good and bad in the use of science. Museums are uniquely positioned to help the public navigate this complicated arena.

The scientific academy places a very high premium on "pure" science. Museums – more than any other institutions – have an obligation to translate "pure" science into the lives of the public through interpretation and action. One of the surprising discoveries that I experienced when I moved from the university world to the museum world, was the remarkable public trust that museums enjoy. In a university context, it has always been

\* Field Museum of Natural History, Chicago, Illinois, USA.

frustrating to me that a statement by a professor on a scientific matter of consequence to the public – on global warming, on habitat loss, on environmental degradation, and the like – would be met with skepticism and doubt because of the certainty that another professor at a different (or sometimes even the same) university could assert a differing and opposing view. This inevitably diminishes the value and impact of academic interpretation of science for the public.

This is not so for museums. To a remarkable extent – at least in the American context, when a museum scientist speaks, that interpretation is accepted as authoritative and nearly conclusive. The voice is the institution's, not the individual scientist's. This is dismaying to me as a long-term member of the academic world (authority should come from the track record of the scientist, not from the institution that employs her). Nevertheless, this is a reality that museums must recognize and deploy in fulfilling our responsibilities. It is both an advantage and a burden to be endowed with such trust.

Translating the public's trust into understanding and action requires creative, focused care. In the current political environment so divided and so antagonistic to ideas outside of particular worldviews, great care is necessary in walking the narrow path that maintains trust and makes clear the right action to be taken. However, it is precisely because we are not Government, we are not Academia, and we are not Non-Governmental Organizations with specific agendas that we are so trusted. Much of the world longs for trustworthy commentary on scientific matters that are subject to political obfuscation and they turn to museums for that commentary. We owe it to those audiences to deliver.

Twenty-five years ago, the Field Museum began an effort to translate the collection-based science of the museum into meaningful action that would significantly preserve biodiversity on this living planet. In 1993, the centenary of the Field Museum's founding, the visionary president of the Field Museum at the time, William "Sandy" Boyd, saw the museum's highest relevance in focusing on how it could best use the information contained in its collections to mitigate the impact of human beings on the environment. This unit has morphed into the Keller Science Action Center at the Field Museum.<sup>1</sup>

Around that time, Sir Peter Crane became the vice president for Academic Affairs. The museum had re-organized its scientific staff into two

<sup>1</sup> <https://www.fieldmuseum.org/science/research/area/keller-science-action-center>

units. One combined the staffs of Botany, Geology, and Zoology into the Center for Evolutionary and Environmental Biology (CEEB). The second, the Center for Cultural Understanding and Change, was comprised of anthropologists and intended to extend beyond the realm of academic anthropology to focus on cross-cultural understanding. I share these organizational details to convey another important reality of museum effectiveness – the need to constantly adapt the institutions organizational structure to its changing role. The intent of this re-organization was to enhance the relevance of museum collections and research. At this moment in the history of the Field Museum, the focus of this concern for relevance was the immediate Chicago region.

Very quickly, the staff who were focused on translating the research of the museum into environmental action saw that a traditional academic approach to the urgencies of conservation would be inadequate. Under the leadership of Debra Moskovits the Office of Environmental and Conservation Programs (ECP) was created. This separate unit had a total of 2.5 full-time equivalent staff. This small staff began to support and energize local and international partnerships. It created a coalition of local organizations dedicated to enhancing the natural environment of the Chicago region. From this initial work, two entities were created, Chicago Wilderness and The Chicago Cultural Alliance. Chicago Wilderness was begun in the Field Museum with a gathering of some 30 groups concerned to preserve the natural assets of the Chicago region. Chicago Wilderness continues to flourish and has grown to an organization that now includes more than 200 organizations in the Chicago region ranging from the US Fish and Wildlife Service to corporations to small local garden clubs. Their work is to advocate for the enhancement of environmental conservation in the Chicago region. It is a powerful voice in the region. The Chicago Cultural Alliance consists of nearly 100 core members and partners who represent the cultural and ethnic organizations of Chicago working to connect, promote, and support centers of cultural heritage for a more inclusive Chicago.

At its beginning, the ECP also collaborated with Conservation International on its rapid assessment program for conservation and environmental assessments of various regions. The Field Museum dramatically changed the model developed by CI. The Field recognized that the crucial, indeed, the culpable element that lies at the very heart of every single conservation effort is – human beings. The Field Museum deployed a conservation approach in all of its work that has proven extremely effective in the twenty years of its use. The term we use is “quality of life” conservation.



Quality of life conservation involves listening to the inhabitants of the target region with great care to let them inform us of those aspects of their lives that are the most valuable, most prized, and therefore the most likely to be preserved with enduring commitment. In the neo-tropics this approach has meant that indigenous people's voices are given a volume and level of privilege that is rare if not unprecedented. In every one of the 30 Rapid Inventories (23 in the Western Amazon)<sup>2</sup> conducted by the Field Museum in the past 20 years, there have been scientists who rappelled from helicopters into the target area to conduct these inventories. On these teams of some 30–40 scientists are the expected botanists, herpetologists, geologists, ornithologists, mammalogists, ichthyologists, and entomologists, but also social scientists specially trained to elicit from indigenous populations those elements most essential and prized for their highest quality of life.

It may seem surprising at first blush to know that in every instance over the past 30 Rapid Inventories quality of life concerns have been exactly coincident with conservation concerns. Indigenous populations want their lives in the rain forest to be protected. They do not aspire to western, urbanized values. They do not wish for money and technology. They want to preserve what they understand to be the quality of their lives.

The scientific teams of our Rapid Inventories (which always include expertise from regional institutions) then synthesize their findings after four weeks in the field. They assess the threats, opportunities and assets that have been discovered. This assessment is then displayed in the form of a conservation roadmap that is presented to local, regional, and national authorities. In many instances, the roadmap has been imparted to representatives of extractive industries as well. These presentations are not the end of the Field Museum's involvement. Members of the team continue to work with policy makers, political authorities, local leaders, and others to encourage the implementation of the conservation roadmap.

The Field Museum's approach has been successful. In the past 20 years, we have provided the governments of Peru, Bolivia and Ecuador with the results of Rapid Inventories. This work has resulted in the creation of 18 protected areas covering some 9.6 million hectares of precious Amazonian rainforest. We continue to work in this region and are focusing on new work in Guyana and Columbia. When all regions in which we have worked are included (We have worked in China, Cuba and the United

<sup>2</sup> <http://fm2.fieldmuseum.org/rbi/results.asp>

States as well), the Field Museum is responsible for contributing to the protection of more than 12.5 million hectares of land.

There are three fundamental elements to the Field Museum's approach. Each is essential.

- 1) A broad spectrum of stakeholders and scientists must be involved in building a consensus of conservation action.

- 2) The locally affected population must be given a prominent voice in the building of that consensus.

- 3) The process must result in products that can actually be used by decision-makers to turn the conservation roadmap into policy and action.

Five years ago, a group from the University of Maryland with the awkward name the National Socio-Environmental Synthesis Center offered the scientific community a definition of a "new" term: "translational ecology". Their definition is long and academic, but it calls for "boundary-spanning, environmental science that leads to actionable research".<sup>3</sup> Colleagues at the Field Museum have been pursuing this wise path for 20 years. They have been spanning boundaries of regions, disciplines, and politics, and they have done so to encourage action. It works. It works because of the trust that museums have built over the past centuries. It works because of the perceived scientific and political neutrality of museums. And it works because it results in outcomes that lead to action. It is my view that this sort of action is the future of natural history museums. Our collections are the repositories of the history of life on earth. That history must be the basis for the preservation of life on earth in addition to its history.

<sup>3</sup> <https://www.sesync.org/what-is-translational-ecology-definition>



- ▶ **III. Lessons and Insights from Zoological Gardens' Research and Outreach**



## 5 THE CONTEXT OF ZOOS AND AQUARIUMS

THOMAS KAUFFELS\*

### Introduction

Zoos and aquariums look back at a long history. Just like the interests, needs, and cultural practices of humankind changed over time, the roles of zoos and aquariums altered throughout history. This contribution discusses in the following the development of zoos and aquariums and points out how the expectation of the communities these institutions serve interacts with the activities that zoos and aquariums display. For this purpose, the evolution of zoos and aquariums is explained in four stages. A first section shortly lays out the history of zoos and aquariums as animal-keeping facilities. Subsequently, the change from passive observation of animals to breeding and helping species is elucidated in a second section. The third section focuses on the relationships between different zoos and describes how the character of these relations changed from rivalry to support for cooperative breeding. The first three points partly cover common perceptions of the core role of zoological gardens, but there are also activities and connections outside this remit, which will be touched on in the fourth section discussing the status quo of zoos and addressing the question of what makes a good zoo. This contribution closes on an outlook on the role of zoos and aquariums within the so-called West and on an international level, and highlights our joint responsibility to engage and make a compelling argument for a bountiful future for nature.

### A short history of animal-keeping facilities

The history of keeping wild animals in human care<sup>1</sup> reaches back more than 5,000 years. Already in the time of the Pharaohs in Egypt, royal animal collections included elephants, giraffes, antelopes, and ostriches, to name a few, and a Chinese Emperor in the 12th century BC established a “park of knowledge” (Hoage et al. 1996, p. 9), showing tigers, tapirs, rhinos, and snakes.

\* Director, Opel-Zoo, Kronberg, Germany, and Chairman, European Association of Zoos and Aquaria (EAZA), UK.

<sup>1</sup> For an overview of the history of zoological gardens, which exceeds the chronological outline presented in the following, see Baratay and Hardouin-Fugier (2004) and Verband Deutscher Zoodirektoren (2012).

What is better known is the keeping of wild animals in the Roman Empire – be it for food or more infamously for staged fights with gladiators, prisoners, or each other. Lions, hyenas, leopards, giraffes, and rhinos were presented and, in most cases, killed. The scale of this slaughter was enormous, with 5,000 or so animals being transported and kept alive for a single event: the opening of the Coliseum in Rome in 80AD. The end of the Roman Empire also called a halt to the import of exotic animals into Europe for centuries. Imports started again with the crusaders and the early explorers. At this point, the animals were kept in so-called menageries, which were connected to the aristocracy as the animals were considered symbols of power and wealth. Concurrently, the growing cities started to keep endemic wildlife like deer or bears, and the ruling classes established big game parks for hunting.

In the early 18th century, King Louis XIV was the first to incorporate a new kind of menagerie into the designs for the transformation of the Palace of Versailles, in which there was a small central pavilion for the royal family, and the enclosures for the animals were built in a circle around this pavilion. This menagerie was the template for the oldest extant zoological garden, which is the Tiergarten Schönbrunn in Vienna, Austria, established in 1752.

In the 19th century, the first zoos were founded, which declared themselves institutions for leisure and the education. They were open for all people, not only for aristocrats. The first zoo of this new generation was located in London. It had opened in 1828 following advice from “Sir Stamford Raffles, a colonial administrator and founder of the colony of Singapore, ... [according to whom] there was a need for a collection of animals for scientific purposes” (Mullan & Marvin 1999, p. 109). While access to the Zoological Gardens in London was restricted to members and their guests, it was the opening of the facilities to the public that first established the term “zoological garden” on an international level (Mullan & Marvin 1999).

Unfortunately, the term “zoological garden” is still not adequately defined. The definition in the “EU Zoos Directive” (European Union 2015), according to which a zoo is defined as an institution with more than six species of exotic animals and open for the public more than seven days in one year, leaves a lot of room for interpretation, and fails to cover the common public perception.

Back to the history of zoos: The new development changed the reason for keeping wild animals from status seeking to educating a public thirsty

for knowledge. The aim of these zoological gardens was the compilation of scientific understanding of animals; thus, they strove to collect as many species as possible. This ambition inescapably led to overstocking animals in inadequate facilities, giving the impression rather of a living museum than of a zoological garden.

This changed in the beginning of the 20th century when a new concept of animal presentation was established first by Carl Hagenbeck in Hamburg and subsequently by the Tiergarten Hellabrunn in Munich. Hagenbeck had the goal of presenting animals as openly and freely as possible. In 1907, he opened the first zoo without bars and used concrete copies of habitats to show the animals in a simulacrum of their natural environment. This progressive action was the beginning of a change from animal collections acting as taxonomic catalogues to illustrating animals in a near natural context (Reichenbach 1996).

How to keep animals in modern zoos was well explained in 1956 in the founding document of the Georg von Opel Freigehege für Tierforschung (Georg von Opel Sanctuary for Animal Research). It clearly speaks in favor of keeping animals in social groups, in naturalistic exhibits and wherever possible without bars between the visitor and the animals (Georg von Opel – Freigehege für Tierforschung von Opel Hessische Zoostiftung 2016; see also Kauffels 2010).

This was quite ambitious for 1956, but it is standard for zoos today.

### **Change from passive observation of animals to breeding and helping species**

The previous section focused more on the architectural changes in animal-keeping institutions, but the evolution of exhibits also reflects the change in human attitudes to animals.

Before the drive for scientific inquiry at zoos, animals were brought in to satisfy human curiosity, and zoos operated at the same level as other public spectacles of the time. Their mode of operation primarily relied on the import of single zoological specimens that lived their lives on show, and were then replaced by single specimens when they died. Due perhaps to the enormous expense of importing wild animals one by one and driven also by the increase in scientific knowledge about the animals in question, zoological gardens learned to breed animals, and therefore had to create enclosures that could house pairs or groups of animals.

The building of this expertise led to the realization that zoos could help mitigate the phenomenon of human activity leading to the extinction of



species, which was becoming increasingly visible. One of the first examples was the rescue of the Père-David's deer by the Duke of Bedford in the early 20th century. This deer species was known to be extinct in the wild in their home region in China, but was known from the garden of the Chinese emperor in the Forbidden City in Beijing. In the 1870s, a few specimens found their way to the Zoological Gardens of London, Paris, and New York, where they were kept and bred. After the Boxer Rebellion in 1900, during which all animals in the Chinese Emperor's garden were killed, the species was entirely extinct in China. In the years following, the Duke of Bedford collected all specimens of the Père-David's deer from all zoos which had been keeping them and bred the species in his private estate (Baratay & Hardouin-Fugier 2004). These few animals led to an astonishing recovery of the species – to a current worldwide population of more than 3,000 animals today, including in China.

This success was led by a single person, who had the resources and the desire to make a difference; yet there are few such people. However, we also know now that you should not place all your animals in one location where the entire species could be wiped out by a single outbreak of disease. This realization, however, occurred late in the history of zoos such that cooperation between different institutions started from a different source, as explained in the following section.

### **Change from rivalry of zoos to cooperative breeding**

At this early stage in our development, zoo decision-makers were just beginning to understand that working together to make a difference for endangered species was more important than trying to collect every possible species for exhibition to the public. A very good example of this realization is the rescue of the European bison, which was achieved by a few zoos in Europe that started to work together in 1923, exchanging animals for breeding and founding the first studbook records of any species ever in 1932. The last European bison in the wild was shot in 1927 (Baratay & Hardouin-Fugier 2004).

Around that time, the Swiss citizen Prof. Dr. Heini Hediger, zoo director in Basel, Berne and Zurich, postulated the four pillars of zoo biology, two with a local or regional focus, namely leisure and education, and two with a more global focus, namely conservation and research (Hediger 1965). Today the European Association of Zoos and Aquaria (EAZA) alone runs over 400 population management programs for different species, all based on cooperation between a similar number of institutions, and the

World Association of Zoos and Aquariums (WAZA) has explicitly dedicated itself to sustainable population management for the purposes of both animal welfare and species conservation (WAZA 2005, 2015a, 2015b).

Arguably, the early development of zoos was based strongly on enlightened self-interest – to ensure that species were available to be shown to the public. Nevertheless, the logic of saving species was becoming unavoidable: Prof. Dr Bernhard Grzimek, the well-known former zoo director of the Frankfurt zoo, helped establish the concept of zoo-led *in situ* conservation work by drawing an explicit link between the animals in the Frankfurt zoo and their conspecifics in the natural habitats of their region of origin.

In the last 25 years or so, zoological gardens have become increasingly involved with *in situ* conservation, and many related projects continue because of financial and staff support from zoos. Zoos aim to provide their support in connection with globally acting partners like the Species Survival Commission of the International Union of Conservation of Nature, the world's largest conservation organization, which has observer status at the United Nations. EAZA zoos alone, with their annual attendance of over 140 million visitors, spend millions of Euros on *in situ* conservation, making this association a powerful contributor to conservation, even above WWF or Greenpeace.

### **Where do zoos stand today and what is a good zoo?**

I will try to answer this question using six short questions and answers.

Today, zoos are among the most successful leisure destinations almost everywhere they are located. EAZA zoos are visited by more than 140 million visitors annually (EAZA 2019). In Germany, the member zoos of the German Association of Zoological Gardens (Verband der Zoologischen Gärten, VdZ)<sup>2</sup> have had an annual attendance of over three times that of the federal soccer league (Bundesliga) for many years. Zoos are therefore some of the most successful cultural institutions in most European urban societies.

Zoos are visited by people of all social and economic backgrounds, all religions, all nationalities, all educational levels and all ages. Zoos have a huge potential to integrate all these social groups and they have the means at hand to initiate a change of mentality in their visitors to appreciate na-

<sup>2</sup> For information on current numbers of zoos which are members of the organization, on visits paid to these zoos and on vertebrates kept at these zoological gardens, please visit <https://www.vdz-zoos.org/>

ture and biodiversity. Let us not forget either, that zoos are one of the few leisure destination types which can be experienced as a family.

Why do they have this potential? Because all these zoo visitors want to see animals! This seems obvious, but I would like to explain further why I emphasize this point.

### **Question: What are the strengths and the weaknesses of our Zoos?**

The overall professional strength of our zoos is the practical ability to manage small populations of wild animal species, especially those on the brink of extinction. This is our main expertise and no other body, institution or association is able to do that. We have the animals and with them we can generate empathy, carry out research, and educate the visitors, both actively through specialist programs and/or passively by piquing their curiosity. In this sense, the strength of zoos comes from placing wild animals and visitors in proximity.

I strongly believe that the number and diversity of zoological institutions is an important factor here in that the European public is never far from a zoo. Because of this, our public influence is more evenly spread, meaning that every zoo has the opportunity to play a role in promoting nature to its local community. A model that prioritizes regional mega-zoo hubs cannot have the same local influence, and will therefore have less effect on the behavior and attitudes of visitors.

While our visitors and their interactions with our animals are our strength, they are also our weakness. Judgement of zoos by the public is often based on factors that are not specific to zoos. We cannot base our presence solely on the animals in our care or on the good work we do for conservation and scientific research alone – why? Because the visitor experience has to be a pleasant one, including facilities that are clean and well maintained, staffed with friendly faces and easy to reach. A good zoo cannot neglect its duty to its visitors, because a visitor that is not cared for will not be receptive to our messages.

### **Question: What makes our zoos unique?**

Only good zoos and aquariums have the expertise to provide high standards of welfare and husbandry to the animals in our care, and to use those skills for the conservation of species as well as for the promotion of zoological science. Moreover, all this has to take place in full view of visitors who we help to learn about the intrinsic value of nature and who we influence to behave more sustainably in their daily lives. If they see the

animals their actions could destroy, they are more likely to reconsider their choices.

### **Question: What is expected from a zoo?**

The expectations of zoos differ depending on whom you ask: visitors, media or professionals.

Visitors expect a pleasant day in nature with their children, seeing animals that have made up a large part of their childhood imaginations. They want to learn, experience, and enjoy. They expect us to provide the best possible welfare, but they still expect to see the animals in their exhibit, they want to be close, and sometimes even want to touch the animals. Increasingly, we recognize that visitors also want to see proof of our commitment to *in situ* conservation.

Concerns for welfare and conservation are often driven by the media; in our societies, the media is the hungriest beast of all, and zoos are expected, like any other publicly visible institution, to live up to an ideal that is often impossible to reach. Moreover, the media thrives on division and controversy, so that zoos need to work tirelessly to prove our commitment to both the individual animal and to the species itself. We welcome this pressure.

Zoo professionals have their own expectations: We want to educate visitors on conservation issues in their widest sense. Given that most visitors arrive only with the expectation of an interesting day out, we run the risk that the intensity of our expectations will overwhelm them. Thus, we need to understand clearly the context in which we operate – and work to overcome its limits.

This leads to the fifth question:

### **Question: What is a successful zoo?**

I am convinced that a successful zoo has a very good bond with its community both with the public and with the authorities. It is respected for its animal husbandry, for its animal welfare, for its appearance, and for the impression it gives to visitors on both the animal and attraction level.

Being successful on the global scale should be the aim of every zoo, but if that is not possible, due to the scale of the institution or its community, it should still be possible for that zoo to make a valuable contribution. It should not be judged as lesser than the large zoos, which already have a global influence. We need all types of institutions to help us realize our responsibilities to society.

**Question: What is our overall (realistic) goal and how can we reach this goal?**

In my opinion, a realistic goal for zoos is to meet the expectations of their visitors, even as those expectations change over the generations. When my parents visited zoos as children, their expectations were different from mine, which are different from those of my sons, and will be different for their children. What remains constant is our presentation of animals. In Germany, only 2% of the population has the resources to travel to see our animals in their natural habitats. Consequently, without zoos, the empathy for animals and the desire to see them protected can never be maintained; it is this goal that we must strive to reach.

**One last question: Who is paying our bills?**

This is a very important question. Each of our zoos has to pay all its bills at the end of the day. Throughout our community of (European) zoos, there are different models of how a zoo operates: As a zoo you do not have to compromise on anything if you are privately owned and earn at least 1 coin of your currency more than you cost. If, however, you have a subsidized zoo and you depend on a board whose composition is affected by political elections, it is a lot more difficult to fulfill the overall agenda agreed by EAZA or, on the global scale, by WAZA.

**Conclusion**

There is no ideal way, no template, which will work for all zoos worldwide or even within the EAZA region, but there are “essentials”, which each of our member zoos should be aware of and follow. Therefore, associations like EAZA or WAZA are umbrella organizations and these umbrellas have to be open in order to be functional and protect instead of being used as a stick.

We as zoo professionals who grew up in the Western European context after World War II have to consider the different approaches and attitudes towards animals in the different regions of the world. We can offer our knowledge, but we cannot expect the growing societies in the developing world to have a comparable attitude towards animals in the short term. European cultures needed decades, not to say centuries, to develop this understanding for animals.

The attitude of our zoos should be: Our professional expertise and our passion can contribute to a rich and bountiful future for nature and should do so wherever possible. We need to be proud of what we have achieved

and of what we can achieve, and we must continue the search for ways and means to contribute more. We need to bring our communities into the heart of our mission, transmitting our passion to those who seek it by entering our institutions, and seeking to influence those who do not. We need to work together across communities, regions, nations and continents to form a network of science-based, value-driven expertise to protect species and to help humanity to hold nature in their hearts with love.

## Bibliography

- Baratay, E. & Hardouin-Fugier, E. (2004). *Zoo – A history of zoological gardens in the West*. Reaktion Books: London.
- EAZA (2019). Members. Last accessed on October 17, 2019, at EAZA <https://www.eaza.net/members/>
- European Union (2015). EU Zoos Directive Good Practice Document. Last accessed on October 17, 2019, at [https://ec.europa.eu/environment/nature/pdf/EU\\_Zoos\\_Directive\\_Good\\_Practices.pdf](https://ec.europa.eu/environment/nature/pdf/EU_Zoos_Directive_Good_Practices.pdf)
- Georg von Opel – Freigehege für Tierforschung von Opel Hessische Zoostiftung. (2016). Forschung im Georg von Opel Freigehege für Tierforschung – eine historische Betrachtung. *Meso Magazin* 32, 6-7. Last accessed on October 17, 2019, at <https://www.opel-zoo.de/files/0/1/0/2534.pdf>
- Hedinger, H. (1965). Mensch und Tier im Zoo: Tiergartenbiologie. Albert Müller Verlag: Zürich/Stuttgart/Wien.
- Hoage, R.J., Roskell, A., & Mansour, J. (1996) “Menageries and zoos to 1900”. In R.J. Hoage & W.A. Deiss. *New worlds, new animals: From menageries to zoological park in the nineteenth century*. Johns Hopkins University Press: Baltimore and London, pp. 8-18.
- Kauffels, T. (2010). Opel-zoo Kronberg – Der Zoo im Taunus: 50 Jahre Georg von Opel-Freigehege für Tierforschung. Societäts-Vlg: Frankfurt am Main.
- Mullan, B. & Marvin, G. (1999) *Zoo culture: The book about watching people watch animals* (2nd ed.). University of Illinois Press: Urbana and Chicago.
- Reichenbach, H. (1996). “A tale of two zoos: The Hamburg Zoological Garden and Carl Hagenbeck’s Tierpark”. In R.J. Hoage & W.A. Deiss. *New worlds, new animals: From menageries to zoological park in the nineteenth century*. Johns Hopkins University Press: Baltimore and London, pp. 51-62.
- VdZ (n.d.). Verband der Zoologischen Gärten e.V. Last accessed on October 17, 2019, at <https://www.vdz-zoos.org/>
- Verband Deutscher Zoodirektoren (ed.) (2012). *Gärten für Tiere: Erlebnisse für Menschen*. J.P. Bachem Verlag: Köln.
- WAZA. (2005). *Building a Future for Wildlife – The World Zoo and Aquarium Conservation Strategy*. WAZA Executive Office: Berne. Last accessed on Sept 10, 2019, at <https://www.waza.org/wp-content/uploads/2019/03/wzacs-en.pdf>
- WAZA. (2015a). *Caring for Wildlife: The World Zoo and Aquarium Animal Welfare Strategy*. WAZA Executive Office: Gland. Last accessed on Sept 10, 2019, at [https://www.waza.org/wp-content/uploads/2019/03/WAZA-Animal-Welfare-Strategy-2015\\_Landscape.pdf](https://www.waza.org/wp-content/uploads/2019/03/WAZA-Animal-Welfare-Strategy-2015_Landscape.pdf)
- WAZA. (2015b). *Committing to Conservation: The World Zoo and Aquarium Conservation Strategy*. WAZA Executive Office: Gland. Last accessed on Nov 4, 2019, at [https://www.waza.org/wp-content/uploads/2019/03/WAZA-Conservation-Strategy-2015\\_Portrait.pdf](https://www.waza.org/wp-content/uploads/2019/03/WAZA-Conservation-Strategy-2015_Portrait.pdf)

## 6 ZOOS AND PUBLIC CONSERVATION EDUCATION

GLORIA SVAMPA GARIBALDI\*

*“Humans are currently inside a bottleneck of overpopulation and wasteful consumption... In order to pass through the bottleneck, a global land ethic is urgently needed... based on the best understanding of ourselves and the world around us... We will be wise to listen carefully to the heart, then act with rational intention”.*  
(Wilson, E.O., 2002, pp. 28-29).

The “global land ethic” claimed in *The Future of Life* by the famous scientist Edward O. Wilson as the crucial solution for the dramatic global crisis affecting the planet is on the same wavelength as the global “ecological *conversion*” invoked by Saint John Paul II (2001) and recalled by the Holy Father Francis in his Encyclical Letter *Laudato si’* (Pope Francis, 2015). As the Holy Father reminds in this important document, the scientific community is seriously concerned about biodiversity loss and the damage caused by human beings, who have managed and consumed nature without consideration for the future. We all are aware that a true *conversion* is urgently needed. Not only with regard to the ethical and moral meaning of the word, which can be referred to a consciousness raising toward the serious problems and the misery that many populations are facing, but also to its meaning of change in our attitudes and ways of managing natural resources. Biodiversity is disappearing at an unprecedented rate, much faster than the rate with which we can afford to study and monitor threatened populations. To date, we have identified and described only 15% of the organisms living on Earth and, following the assessments of the International Union for Conservation of Nature (IUCN, 2018, 2019b), one quarter of them are already threatened with extinction (Larsen et al., 2017). What about the future of the 85% living species that we still do not know? How can we halt and reverse nature loss? We should *listen to the heart* and then *act* rationally. From this perspective, zoos<sup>1</sup> could be the best partners to take up the challenge of changing attitudes and day-to-day life, with the goal of preserving a healthy planet. Modern zoo exhibits have a great potential

\* City Museum of Zoology of Rome & Italian Association of Zoos and Aquaria.

<sup>1</sup> In this text the word “zoo” always refers to zoological gardens, aquaria and other parks falling within the definition of the World Zoo Conservation Strategy (1993) and of the European legislation.

for inspiring conservation (Gwynne, 2007). Moreover, if we really want to achieve more sustainable relationships with nature, decreasing the negative impact of humans, it requires large numbers of people to change their philosophy of life and their consumptive behaviour. Elite units cannot make the difference. Hence, the large number of people attending zoos is relevant to our goal. Moreover, biodiversity protection needs to be addressed through ongoing conservation education (UNESCO, 1997; Hill, 1999), so that environmental understanding and participation become automatic in our lives. Without this, the focus of environmental management will tend to be on repairs and temporary fixes, rather than on long-term solutions. Modern zoos have focused their action plan on integrated conservation activities. Effective conservation education is part of them and it represents one of the most ambitious goals of the international zoo community. Zoos' potential is unique and immensely large. No office-based organization can showcase conservation as well as zoos (Stanley-Price, 2005). Zoos worldwide welcome more than 700 million people a year, a figure that, even if based on different calculation methods, is confirmed in several published reports (Gusset & Dick, 2011, pp. 566-569; Hildebrandt et al., 2017, p. 54) and very probably underestimated, if we consider that more than 195 million visitors, 50 million of whom are children with their families, have attended the 233 zoos affiliated to the USA Association of Zoos and Aquaria (AZA) in 2016 (AZA, 2016) and that 140 million people visit the 371 member institutions of the European Association of Zoos and Aquaria every year (EAZA Strategic Plan 2017-2020, p. 7). Most importantly, the attendance of zoos is composed of visitors of any age, culture, language, religion, social role, and personal story. Each one of these visitors constitutes an opportunity for us to demonstrate the wonders of nature and the products of natural selection and to deliver messages about conservation. If these messages are correctly delivered, each one of these visitors can become aware that he or she can make a difference, act and play a personal role in building a future for humankind and for wildlife (Stanley-Price, 2005).

The large number of people attending zoos is frequently mentioned in presentations regarding the work of these institutions. However, in this contribution I would like to move the focus on the distribution of zoos worldwide, setting here its value. If we look at a global map of zoos, reporting all of them and not only the members of the World Association of Zoos and Aquaria (WAZA, 2005) or of the above-mentioned regional associations, we would be impressed by the huge number and distribution of these institutions in every corner of the world. This gives them a great



potential and a very precious tool for any task force intentioned to work in coordination, for seeking the sustainable and integral development that, we believe, could change the world. Zoos can be considered as “*in situ* education stations”, powerful “observatories” that, having direct and deep knowledge of the local culture, language, history and politics, people’s relationships with nature, negative or positive attitudes, can help in finding the best and most effective way of delivering conservation messages. We are living in the “communication era”. Despite that, it is evident that till now our educational messages have not been able to reach and, most important, to influence the behaviour of most our recipients. One of the possible answers to this problem could be that we have underestimated the difference of cultures and, consequently, we should enlarge partnerships, involving more and more the local communities. Scientists must communicate more widely with societies, but they need to be educated on how to communicate. In this respect, zoos can be really good partners in this outreach research work.

Another relevant aspect we should keep in mind is that many people are, for sure, informed and aware of the environmental crisis, but they feel powerless in finding good solutions and in understanding how they could give a personal contribution. Consequently, they resign themselves to fate, hoping to be able to face problems, when they will come out with evidence. Experts in conservation psychology highlight that people are more likely to change behaviour if they see a clear role for themselves and feel that this role is not optional, but critical to the success of an initiative (Kaplan, 1990; Folz & Hazlett, 1991). If we look at current topics and modalities of educational activities in zoos, we can easily verify that they always include and value the active involvement of visitors and that any environmental problem introduced by zoo educators is followed by the recommendation of what “we can” do to halt or to reverse it. In fact, if we want to overcome resignation and discouragement, we can never forget to recall reasons of hope and to emphasize, as the Holy Father has done in his Encyclical Letter (Pope Francis, 2015) that *things can still change*, if we act with rational intention. Conservation in action is the goal that modern zoos have shown to be able to achieve.

Taking for example the European zoo community, EAZA zoos have run successful conservation campaigns that have always included education and awareness projects and that have been very effective in moving public opinion. Among them, very famous is the “Bushmeat Campaign”, during which zoos have been able to collect over 1.9 million signatures. It has

been the largest petition ever received by the European Parliament (West and Dicky, 2007). Educational campaigns spread knowledge and let people understand problems that appear to be very far from our daily life, while they are strongly influencing it. The EAZA Silent Forest Campaign, e.g., tells about the illegal trade of Asiatic song birds with the ultimate goal to save these species from extinction and, in so doing, seeks to safeguard the whole tropical forest ecosystem, which is an irreplaceable natural resource for all living beings of the planet. In this way people become able to make connections and to understand the web of life, discovering that the survival of small beautiful birds, with a musical song, can influence, in the end, even the global climatic changes.

The large distribution of zoos in the world is powerful in spreading correct environmental information and education to new audiences. As a matter of fact, natural history museums and botanical gardens are generally visited by people who are just interested in nature. Zoo public includes also those people who do not currently share our conservation values or who do not have the necessary background to understand the extent of problems and to select the enormous amount of information that nowadays is provided by the media, in particular by the web. If these people do not have the chance to derive information from a reliable source, they are not able to take part in public life and to make informed decisions that are crucial for the environment and for their own future. Zoos, together with botanical gardens, science and natural history museums can represent their competent, independent and respectful reference centers.

The whole zoo staff is, in general, a very good mediator between people and animals. Curators and well-trained animal keepers can play an important role in explaining the zoo's mission, husbandry and care techniques and also the difficult balance that zoos have the task to meet between animal welfare and species conservation needs. In addition, modern zoos have also dedicated teams, in charge of communication and education. During their evolution into environmental research and conservation centres (*World Zoo and Aquarium Conservation Strategy*, 2005) zoos have in fact empowered their staff with experienced zoo educators. In the 20th century, up until the 50s, zoos were used to pursue their goal in education mainly through the exhibition of their animals and the information that was readable on their signs. They looked like living encyclopedias or natural history cabinets, actually very useful and appreciated by people of those times. About twenty years later, influenced by the shifting historical and cultural situations, as well as on the wave of the developing education science, zoos started to establish

educational departments with qualified staff, who rapidly evolved into a specialist group and a true task force, capable of networking at national and international level (e.g. EduZoo in Italy, the European Zoo Educator Association, the International Zoo Educators Association) and to involve school children as well as any other target of zoo visitors. The large range of educational activities offered today in zoos includes animal displays in naturalistic exhibits (at least in most zoos, but this is, in any case, the general trend), behind-the-scenes guided tours, interpretative graphics and texts, publications, workshops, unique and interactive multi-sensorial experiences, technology assisted programs, opportunities for communicating with staff and educators and outreach programs beyond the walls of the zoo (Sterling et al., 2007). This provides different chances to zoo professionals to establish contact with people, thus encouraging positive values and attitudes toward animals and their natural habitats. These values, together with the acquired correct information, are the driving force that should empower people to act (Reading & Miller, 2007).

Generally, when we talk about the role of zoos in wildlife conservation, we always mention the importance of their *ex situ* endangered species populations, as a precious reservoir of genetic pools and as valuable resources for scientific research and knowledge. More rarely we emphasize the importance of the unique heritage of experience that zoos can provide, through their professional staff. These people have a deep knowledge of animal husbandry and biology, but also of human behaviour. Therefore they can be precious in training local professionals and in teaching native people how and why it is so important to protect wildlife. Today the role of zoo educators is not confined inside the zoo borders or the zoo school. They are motivated and experienced professionals, whose contribution is fundamental to make successful zoos and aquaria conservation organizations. The “educational challenge” (see Pope Francis, 2015) that is facing us entails not only a commitment in our own “nature consumer” countries, but also *in situ* and particularly in biodiversity hotspots, where people risk losing their treasures, before becoming aware of their value.

Measuring the effectiveness of a zoo visit in changing public awareness and behaviour is honestly difficult and it is still one of the most debated topics by conservation psychology and science communication research (West & Dickie, 2007; Balmford et al., 2007). Data collections and scientific investigations are still needed to understand better how environmental values develop, what are the effects of experiences with the natural environment, what zoos could do better or more to help a sustainable

future and wildlife conservation. The outcomes of scientific research work carried out so far in the United States and in Europe are encouraging, but sometimes contradictory and highlight the complexity of evaluating levels of awareness and feeling toward nature. Since Aldo Leopold (1933; 1949) argued that an ethic of care was an essential part of humanity's relationship with the natural world, an increasing number of researchers have been studying how caring about nature can develop the formation of an authentic environmental identity (Kahn & Kellert, 2002) and how strong are the relationships between a psychological connection with nature and environmental sustainability (Schultz, 2002).

In *The Future of Zoos and Aquariums: conservation and caring* (2006) George Rabb, past Chair of the IUCN Species Survival Commission and President Emeritus of the Chicago Zoological Society, and Carol Sanders, conservation psychologist of Brookfield Zoo (Chicago Zool. Soc.), have defined modern zoos, in their essence, as “institutional centers of caring” with respect to the natural world. Rabb is convinced that zoos, in their role of agents for conservation, should foster caring (Saunders, 2003) in each mode of engagement. They should inform and marshal values of nature (*caring that*); provide experiences, stimulating the affective axis (*caring about*); help expressions of caring behaviour (*caring for*), offering opportunities for direct and indirect action for nature conservation. This work of inspiring care for our planet, that could be so good for giving a positive answer to the Holy Father's appeal in the *Laudato si'* (Pope Francis, 2015), is made undoubtedly easier for zoos by the aspect that makes them unique: the presence of live animals. The direct contact with them has an incomparable power in generating emotions, inspiring a sense of belonging and protection. Seeing live animals can touch people's hearts and, if people are able to *listen to their hearts*, they start to *act with rational intention*, looking with different eyes at nature, becoming able to discover its secret networks and to understand the importance of preserving the delicate balance of all living beings (Wohlleben, 2017).

The presence of wild animals in zoos and their effective usefulness in spreading knowledge, fostering environmental awareness and ethics has been and still is the object of hard debate between animal rights defenders, conservationists and zoo supporters. What it is undoubtful is that we would have never known so much of animal behaviour, biology, wildlife veterinary medicine and so on without studying *ex situ* populations. It is also clear that *ex situ* and *in situ* conservation activities, financially supported by zoo visitors and sponsors, have saved at least a good number of

highly endangered species and their habitats from near certain extinction. The positive impact of zoos' conservation activities is documented by successful stories of species which have had a second chance in their habitats, overcoming risks of extinction or even returning to the wild (see IUCN/SSC/CBSG, 2017).

Just to give an example, very recently the Durrell Wildlife Conservation Trust (2018), using the industry best practice Red List Index (IUCN, 2019a) as an indicator of success of Jersey Zoo's conservation projects, has evaluated a positive impact of about 150% on the survival of the 14 species that the zoo is protecting in the wild. Many other examples could be taken, regarding not only big and rich institutions, but also small ones. Italian zoos, in the EAZA network, are supporting research and conservation work in Madagascar, South America, Northern and Eastern Europe, which benefit both animal and human populations.

Holding research and conservation in due regard, at the same time we know very well that without a good conservation education and a different approach to nature the positive effects of those activities would last for a very short time. Zoo detractors respond to this proposal by affirming that modern technology can supply all the information and the education we need. Actually, if we look at data, we have the feeling that they could be right and that we are living in a very high cultured world, where people can find almost everything online. It is estimated (see *Real Time Statistics Project*)<sup>2</sup> that currently more than 1.7 million websites are available in the world and that more than 4 million people are regularly consulting them. The 700 million Google users make 40,000 web searches per second (more than 5 million per day) and view 5 million videos and about 70 million photos per day. Now, if information is not missing, something must be wrong, otherwise we would not be going towards the sixth mass extinction of the planet.

Modern human psychology confirms that nothing can influence our behaviour more than personal experience. People are inclined to care and to protect things they love and it is not possible to love things we do not know directly. Modern times are not at all favourable to direct experiences and this happens mainly in big cities, where most zoos are located and where they benefit the future and the welfare of human populations and not only of wildlife. When we think of human impacts on the environ-

<sup>2</sup> <https://realtimestatistics.org/>

ment, usually we think of consequences such as the loss of biodiversity. However, we are losing not only components of the natural world, but also experiences with nature. Pyle (1993) speaks of the “extinction of experience” as humans have fewer direct, personal contacts with living things. This can lead to *environmental generational amnesia*, where each generation regards the degraded environment they inherit as the “normal” experience (Kahn, 1997). It is this highly risky adjective “normal”, that zoos would like to cancel, joining their forces with all the institutions that are sharing their same vision and mission. If it is true that memory can be awakened by the view or the contact with something special for us, zoo animals, “ambassadors” of the ones still living in wild, can tell stories and can generate emotions able to rouse people and to affect choices that determine our behaviour.

What can we do better? What are the strategies that, with a focus on education, zoos could adopt in order to improve their commitment to conservation?

The European Association of Zoos and Aquaria has defined *Conservation Education Standards* in order to address its membership: “To mitigate the extinction of biodiversity through quality conservation education that raises awareness, connects people to nature and encourages sustainable behaviours in the millions of people that engage with zoos and aquariums annually” (EAZA, 2016, p. 2).

In a recent publication Sarah Thomas, Head of Discovering and Learning at the Zoological Society of London and past chair of the EAZA Education Committee, has highlighted that education in zoological institutions is not confined to programs for schools and children, but includes a wide range of opportunities and experiences for diverse audiences (Thomas, 2016). Conservation education can be thought of as an umbrella term for a whole host of educational programs that contribute to biodiversity conservation. These can be on-site at an institution (Hughes & Allan, 2016), as part of an outreach program in the local community (Jacobson et al., 2006; Cureg et al., 2016) or at a conservation field site (Crudge et al., 2016; Squires et al., 2016).

Modern zoos can strengthen their support to nature conservation and their contribution in changing attitudes and influencing decision makers by including in their master planning “focused legislator, lawyer, and conservation support exhibits as specialized and imaginative as those for children, and also for far more vigorous efforts to reach the people where zoo wildlife actually live” (Conway, 2007, p. 14). Those “education stations” or

observatories spread around the world, that could be so useful in changing public attitudes and values, sometimes need to be supported in developing their standards, in training and qualifying their professionals, in learning new communication tools. Zoo education should be focused also on this goal and the international zoo community should take care of it. This would be an important step forward in achieving the Aichi Target 1 of the *Strategic Plan for Biodiversity 2011-2020* that provides helping people to be “aware of the values of biodiversity and of the steps they can take to conserve and use it sustainably” (Convention on Biological Diversity, 2010).

The project is ambitious. Therefore zoos, botanical gardens, and natural history museums should really join their forces. The City of Rome is proud to be able to quote an early example in its history of this “joint venture” in favour of nature conservation. In fact, a few years after the foundation of the Zoological Garden of Rome in 1911, it was decided that it would be important for research and educational goals to complete the zoo project with a Museum of Zoology. This was the background of the foundation of the present City Museum of Zoology of Rome, which is still preserving precious collections of the Cabinet of Zoology of the Pontifical Archiginnasio. In 1978, the Rome Zoological Garden and Museum of Zoology established their Educational Department, that since that time is successfully running activities for visitors of any target and that today is playing an important social role in cultural integration and in building, under the umbrella of a project financed by the European Union, a “new cultural democracy”, that is using science museums as a tool to engage adults and to promote learning opportunities and social inclusion for disadvantaged groups of people. Hopefully, this small example taken from the history of our city will be a positive and auspicious illustration for the outcomes of this meeting.

The Italian Zoo Association and the Museum of Zoology of Rome are honored to have been involved in the “Noah’s Arks for the 21st Century” Project. They declare their commitment to achieve the goals that will be identified and to involve all the national institutions that could contribute to the success of this initiative.

## Bibliography

- AZA (2019). *About us*. Last accessed on November 22, 2019, at <https://www.aza.org/zoo-and-aquarium-statistics>
- Balmford, A., Leader-Williams N., Mace, G.M., Manica, A., Walter, O., West, C. & Zimmermann A. (2007). Message received? Quantifying the impact of informal conservation education on adults visiting UK zoos. In Zimmermann, A., Hatchwell, M., Dickie, L., & West, C. (eds.). *Zoos in the 21st Century – Catalysts for Conservation?* Cambridge,

- UK: Cambridge University Press, pp. 120-136.
- Convention on Biological Diversity. (2010). *COP 10 Decision X/2: Strategic Plan for Biodiversity 2011-2020*. Last accessed on October 17, 2019, at <https://www.cbd.int/doc/decisions/cop-10/cop-10-dec-02-en.pdf>
- Conway, W. (2007). "Entering the 21st Century". In Zimmermann, A., Hatchwell, M., Dickie, L., & West, C. (eds.). *Zoos in the 21st Century – Catalysts for Conservation*. Cambridge, UK: Cambridge University Press, pp. 12-21.
- Cureg, M.C., Bagunu, A.M., van Weerd, M., Balbas, M.G., Soler, D., & van der Ploeg, J. (2016). A longitudinal evaluation of the Communication, Education and Public Awareness (CEPA) campaign for the Philippine crocodile *Crocodylus mindorensis* in northern Luzon, Philippines. *International Zoo Yearbook* 50(1): 68-83. <https://doi.org/10.1111/izy.12112>
- Durrell Wildlife Conservation Trust (2018). *Rewild our world. Strategy*. Last accessed on October 17, 2019, at <https://www.durrell.org/wildlife/rewild-our-world>
- EAZA (2016, Sept 23). EAZA Conservation Education Standards. Last accessed on October 17, 2019, at <https://www.eaza.net/assets/Uploads/Standards-and-policies/EAZA-Conservation-Education-Standards-2016-09.pdf>
- EAZA (2019). *Members*. Last accessed on October 17, 2019, at EAZA <https://www.eaza.net/members/>
- Folz, D.H. & Hazlett, J.M. (1991). Public Participation and Recycling Performance: Explaining Program Success. *Public Administration Review* 51(6): 526-532. <https://doi.org/10.2307/976603>
- Gusset, M. & Dick, G. (2011). The global reach of zoos and aquariums in visitor numbers and conservation expenditures. *Zoo Biology* 30(5): 566-569. <https://doi.org/10.1002/zoo.20369>
- Gwynne, J.A. (2007). *Inspiration for conservation: moving audiences to care*. In Zimmermann, A., Hatchwell, M., Dickie, L., & West, C. (eds.). *Zoos in the 21st Century – Catalysts for Conservation?* Cambridge, UK: Cambridge University Press, pp. 51-62.
- Hildebrandt, G., Perret, K., Eulenberger, K., Junhold J. & Luy J. (2017). *Understanding zoos: A multidisciplinary consideration about ex-situ-conservation, surplus animals and euthanasia*. Münster: Schöningh Verlag, p. 59.
- Hill, R. (1999). Today shapes tomorrow: Environmental education for a sustainable future – A discussion paper. Last accessed on November 25, 2019, from *Australian Government: Department of the Environment* at <http://www.environment.gov.au/archive/education/publications/discpaper/index.html>
- Hughes, A. & Allan, L. (2016). The Warehouse Wellington Zoofari: school visits to Wellington Zoo for conservation-based learning programmes – an example of effective collaboration between zoos and business. *International Zoo Yearbook* 50(1): 49-60. <https://doi.org/10.1111/izy.12119>
- IUCN (2018). *The Red List of Threatened Species: Summary Statistics*. Last accessed on November 25, 2019, at <https://www.iucnredlist.org/resources/summary-statistics>
- IUCN (2019a). *The Red List of Threatened Species: The Red List Index*. Last accessed on November 25, 2019, at <https://www.iucnredlist.org/assessment/red-list-index>
- IUCN (2019b). *The Red List of Threatened Species: Assessment Process*. Last accessed on November 25, 2019, at <https://www.iucnredlist.org/assessment/process>
- IUCN/SSC/CPSG (2017). *Second Nature: Changing the Future for Endangered Species*. St. Paul, Minnesota: CBSG. Last accessed on October 17, 2019, at <http://www.iucn.org>



- www.cpsg.org/sites/cbsg.org/files/Second\_Nature.pdf
- Kahn, P.H. (1999). "Children's affiliations with nature: Structure, development, and the problem of environmental generational amnesia". In Kahn, P.H., Kellert, S.R. (Eds.), *Children and nature: Psychological, sociocultural, and evolutionary investigations*. Cambridge, MA: MIT Press, pp. 93-116.
- Kahn, P.H. & Kellert, S.R. (2002): *Children and nature: Psychological, sociocultural, and evolutionary investigations*. Cambridge, MA & London: MIT Press.
- Kaplan, S. (1990). *Being needed, adaptive muddling and human-environment relationships*. Proceedings of the Environmental Design Research Association 21, pp. 19-25.
- Larsen, B.B., Miller, E.C., Rodhes, M.K., & Wiens, J.J. (2017). Inordinate Fondness Multiplied and Redistributed: the Number of Species on Earth and the New Pie of Life. *The Quarterly Review of Biology* 92(3): 229-265. <https://doi.org/10.1086/693564>
- Leopold, A. (1933). The conservation ethic. *Journal of Forestry* 31(6): 634-643. <https://doi.org/10.1093/jof/31.6.634>
- Leopold, A. (1949). *A Sand County Almanac and Sketches Here and There*. New York: Oxford University Press.
- Pope Francis (2015). *Encyclical letter: Laudato si' of the Holy Father Francis on care for our common home*. Vatican Press: Vatican City. Last accessed on September 26, 2019, at [http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco\\_20150524\\_enciclica-laudato-si\\_en.pdf](http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si_en.pdf)
- Pyle, R.M. (1993). *The Thunder Tree: Lessons from an Urban Wildland*. Boston: Houghton Mifflin.
- Rabb, G.B. & Saunders, C.D. (2005). The future of zoos and aquariums: conservation and caring. *International Zoo Yearbook* 39(1): 1-26.
- Reading, R. & Miller, B. (2007). Attitudes and attitude change among visitors. In Zimmermann, A., Hatchwell, M., Dickie, L., & West, C. (eds.). *Zoos in the 21st Century – Catalysts for Conservation?* Cambridge, UK: Cambridge University Press, pp. 63-91.
- Saint John Paul II (2001, Jan 17). General Audience: God made man the steward of creation. Last accessed on October 17, 2019, at Libreria Editrice Vaticana [https://w2.vatican.va/content/john-paul-ii/en/audiences/2001/documents/hf\\_jp-ii\\_aud\\_20010117.html](https://w2.vatican.va/content/john-paul-ii/en/audiences/2001/documents/hf_jp-ii_aud_20010117.html)
- Stanley-Price, M.R. (2005). Zoos as a force for conservation: a simple ambition – but how? Guest Editorial. *Oryx*, 39(2): 109-110. <https://doi.org/10.1017/S0030605305000505>
- Thomas, S. (2016). Editorial: Future Perspectives in Conservation Education. *International Zoo Yearbook* 50(1): 9-15. <https://doi.org/10.1111/izy.12134>
- UNESCO (1997). *Thessaloniki Declaration*. Gland: UNESCO.
- Verband der Zoologischen Gärten (2014, September 26). Replik auf den Artikel Zoos manipulieren Besucherzahlen. Last accessed on November 25, 2019, at <https://hpd.de/comment/356#comment-356>
- WAZA (2005): *Building a Future for Wildlife: The World Zoo and Aquarium Conservation Strategy*. Last accessed on October 17, 2019, at <https://www.waza.org/wp-content/uploads/2019/03/wzacs-en.pdf>
- Wilson, E.O. (2002). *The Future of Life*. New York: Vintage Books.
- Wohlleben, P. (2017). *The inner life of animals: Surprising observations of a hidden world*. Greystone Books.

## 7 ZOOS MOBILIZING THE PUBLIC FOR LEGISLATIVE CHANGE

THEO B. PAGEL\*

### Introduction

In his *Laudato si'*, Pope Francis (2015) mentions that:

*The earth's resources are also being plundered because of short-sighted approaches to the economy, commerce and production. The loss of forests and woodlands entails the loss of species which may constitute extremely important resources in the future, not only for food but also for curing disease and other uses. ... It is not enough, however, to think of different species merely as potential "resources" to be exploited, while overlooking the fact that they have value in themselves. Each year sees the disappearance of thousands of plant and animal species which we will never know, which our children will never see, because they have been lost forever. The great majority become extinct for reasons related to human activity. ... We have no such right. (p. 24–25)*

Unfortunately, this is true and I/we – the zoo community – fully agree with this statement. Most of the problems nature is facing are created by humans. Therefore, we need to act – it is our responsibility.

Modern zoological gardens and aquariums have changed over the last decades. Although still today some people see our institutions mainly as leisure attractions, zoological gardens and aquariums were able to position themselves as sites of conservation learning, conservation action and research (Pagel & Spiess, 2011; Pagel, 2012; Pagel, 2016).

As President-elect of the World Association of Zoos and Aquariums (WAZA) and zoo director/CEO of the Cologne Zoo (Germany), I am absolutely convinced that scientifically run zoos are on the right track (WAZA, 2005; WAZA, 2009). Yet there is still potential for further improvement. Besides the knowledge about keeping and breeding wild animal species and conservation education (Dick & Gusset, 2010; Gusset & Dick, 2010), our visitors – society as a whole – are our real potential. Therefore, the title of this chapter “Zoos mobilizing the public for legislative change” is not only a headline but also a main goal of our institutions. With a mantle of economic and public accountability, zoos and aquariums need to not

\* Zoo Director and CEO of Cologne Zoo, Germany, as well as President-elect of the World Association of Zoos and Aquariums (WAZA).

only understand and promote conservation learning but also to work on changes to the legislation and the behavior of people.

Research suggests that however strongly individuals pursue sustainable lifestyles, the overall indicator of whether or not a sustainability initiative will be effective is the involvement of the government. Since the first Earth Summit in Stockholm in 1972, it has been apparent that the largest challenges, namely those involving over-intensive human exploitation of nature, must be addressed through the interaction of governments. We should remember that conflict related to sustainability was (and remains) too large an issue for individual member states to handle. The Earth Summit was therefore a platform for member states to collaborate.

Governments are most often motivated to act in concert when requested to do so by those they govern, that is (in high-consuming industrialized nations), the society or people in general and their voters in particular – all of whom are also our visitors. Zoos and zoo associations, like the Association of Zoological Gardens (Verband der Zoologischen Gärten, VdZ), the European Association of Zoos and Aquaria (EAZA) or the World Association of Zoos and Aquariums (WAZA), should therefore, besides talking to politicians and civil servants, not be afraid to form a part of the environmental lobby, and should motivate their visitors to demand action! This is and can be done by education, lobbying, involvement of the public, and campaigning.

## **Education**

As modern zoos and aquariums increasingly see themselves as centers of education and conservation (Miller et al., 2004), their mission is to be leaders in both areas. More and more zoos create exhibits in which education and conservation increasingly complement and reinforce each other (Rabb & Saunders, 2005; Fraser & Wharton, 2007). Two examples are: the Congo Gorilla Forest (Bronx Zoo, USA) and the Hippodrom (Cologne Zoo, Germany). Visitors get information not only about animals but also about more general aspects of their habitats, such as their sustainable use, related cultural issues, human-animal conflicts, farming, ranching, etc. Often, *in situ* projects are linked to these kinds of exhibits.

In our institutions, we have two kinds of education: formal and informal. All signs and boards or zoo guide booklets in the zoos are part of our informal education. Some of us have even written books about zoos and their work (Pagel et al., 2010; Pagel, 2015).

A lot of us have zoo schools, teachers, volunteers and/or keepers who inform the visitors about the animals and their needs. At the Cologne Zoo,

we have 11 teachers, who come from different school systems and take care of roughly 23,000 young people per year – we could potentially serve three times this number but do not have enough staff. Education for Sustainable Development (ESD) in Germany is a clear task for the education sector (Lucker, 2008). On June 20, 2017, the National Platform on ESD adopted the National Action Plan for the Global Action Programme (GAP) implementation. It defines 130 objectives and over 300 measures to scale up ESD in all areas and at all levels of the German education system (Bundesministerium für Bildung und Forschung, 2017). As this is a public responsibility of the member states, we should try to make much more use out of it.

Here I would like to mention briefly the Sustainable Development Goals (SDG)<sup>1</sup> adopted by all United Nations (UN) Member States in 2015. These are also increasingly part of our education. The SDGs address the global challenges we face. This includes those related to poverty, inequality, prosperity, peace and justice but also climate and environmental degradation. Once more, these 17 SDGs are an urgent call for action by all countries – in a global partnership. We need to jointly work against climate change and preserve our oceans and forests.

Beside the kindergarten and the school sector, my curators and I also teach at the University of Cologne, we are part of a biodiversity course on the higher vertebrates and run a zoo biology course on our grounds. Many other zoos and aquariums are undertaking similar actions of involvement in formal education.

Our advantage is our animals. People are connected to nature and are normally interested in nature. Nevertheless, the world is changing and therefore we must try to maintain the interest of the people. We need to sensitize them better to get them enthusiastic about animals, and we can achieve this goal only if our visitors really enjoy the stay in our zoo and fall in love with the animals they see. Baba Dioum, a Senegalese forestry engineer, presented a paper in New Delhi in 1968 at the triennial meeting of the General Assembly of the International Union for the Conservation of Nature and Natural Resources (IUCN). There he made the following statement: “In the end we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught”. In a way that means we love only what we know and save only what we love – therefore we have to bring people together with nature – especially in our changing and increasingly urbanized and technological

<sup>1</sup> <https://www.un.org/sustainabledevelopment/sustainable-development-goals>

world. Therefore, zoo animals, museum exhibits and plants are the tools which can lead people to change their lifestyle and behavior.

## Lobbying

For several decades, zoological gardens and aquariums have lobbied at governmental and intergovernmental forums on behalf of nature. We do this in concert with other organizations – at all levels from local government to continental and global forums. Our mandate for this comes from public campaigns as described in the following subchapter.

Another resource of zoos is our expertise concerning the threats different species face. Our collaboration with organizations like TRAFFIC, WWF or governmental organizations is already bearing initial fruit. For example, tiger geckos (*Goniurosaurus*) in Vietnam could be one of the next species driven into extinction by illegal wildlife trade. Therefore, the Cologne Zoo and its partners have proposed that these species be listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). These Asian lizards are particularly vulnerable to extinction due to their extremely restricted habitats and over-collection for the international market. Studies of a Vietnamese–German research team, led by Hai Ngoc Ngo of the Vietnam National Museum of Nature in Hanoi and comprising staff of the Cologne Zoo, have provided an overview of domestic and international trade of *Goniurosaurus*, with the main focus on species native to Vietnam. Because of these data, we are now able to apply for listing these reptiles.

This is very important because currently only eight tiger geckos have a species conservation status assessment for the IUCN Red List. All of them were classified either as vulnerable, endangered or critically endangered, but none is currently listed by CITES, which is the only efficient and reliable method of monitoring and regulating the trade of the species on a global scale. The listing of all tiger gecko species from China and Vietnam in CITES Appendix II was proposed jointly by the European Union, China, and Vietnam in 2018.

The Cologne Zoo has already been successful in having another species be included in the listing: the crocodile lizard (*Shinisaurus crocodilurus*), a species for which we have established a breeding and introduction program in Vietnam and just recently had the first youngsters at our Zoo in Cologne (van Schingen et al., 2016).

Another example for lobbying is palm oil. Palm oil can be found in a wide range of products from makeup to pet food. The rising concern is that its current production methods often destroy the areas where the plants are harvested. Therefore, WAZA has become an official member

of the Roundtable on Sustainable Palm Oil (RSPO) at the 72nd WAZA Annual Conference in Berlin, emphasizing its commitment to sustainable solutions that protect the environment. RSPO currently has more than 4,000 members in 92 countries (WAZA, 2018). Being a part of WAZA, we are now able to vote on behalf of the world's leading zoos and aquariums on issues central to RSPO such as deforestation and conservation – we are an active partner. The world zoo and aquarium community is one of the leading groups of conservation funding compared to the other major international conservation organizations. Through our members, who may sell products including sustainable palm oil, WAZA is also able to engage directly with the manufacturers or suppliers. By only selling sustainable palm oil products in our institutions, we can influence the market (Pearson et al., 2014). Our community has the power to change things. In other words: There is no better ambassador than the orangutan...

The use of other sustainability labels, for example the Marine Stewardship Council (MSC) or the Forest Stewardship Council (FSC), is also an option for influencing the market and thus the behavior of our visitors. At the Cologne Zoo, not only guests in the restaurant are served MSC fish – no, all our fish-eaters such as pelicans or California sea lions are also offered this kind of food!

## Involvement

How can we turn our communities into activists for nature protection? Involvement of the public in specific tasks such as beach-cleaning, forest restoration, etc. that foster an affinity for nature and illustrate the necessity of nature protection firsthand are some of the tools we have as zoos and aquariums. Many zoos have active children's/youth groups as well as other volunteers who are interested in such work.

We need to reach out to the young people. One example is the Green Teen Team (GTT). This organization was founded in 2014 by H.S.H. Princess Theodora von Liechtenstein who is not only the founder but also an active participant in the running of the foundation's projects. GTT believes that everyone can make changes in their lives to help save the planet's biodiversity – even or especially children. The homepage of GTT states:

*Therefore the objective is to empower young people to be able to make changes to their lives, the lives of others and the life of the planet. The world's environment is changing before our eyes and even in our short lifetimes. Only a hundred years ago people would not believe that the changes we see now would even happen. All kinds of harmful things have led to our planet reacting nega-*

*tively, from changes in weather patterns and ocean currents to global warming. ... GTT's aims and objectives go towards helping regenerate the planet's biodiversity through engaging young people in conservation projects and educational workshops and summer camps across the globe. GTT is building an active, global community of environmentally engaged teenagers and young people, in a bid to create positive change at grassroots level. (GTT, 2019)*

WAZA will try to cooperate with GTT in future to get the youth of the planet interested, activated and engaged in conservation.

## **Campaigning**

Zoos around the globe run campaigns to serve as a megaphone of conservation and to encourage the public to take active steps. EAZA has been doing this for almost two decades. Unfortunately, there has never been a greater need for effective conservation of our natural world than today. We must demonstrate the value of conservation – to conserve biodiversity by clarifying its meaning for endangered species and the wider global context. Therefore, EAZA runs these campaigns to raise awareness of and funds for major conservation issues.

Table 7.1 shows what has been achieved in the years of campaigning. The Members of EAZA really made a difference for the protection of biodiversity in many parts of the world. To sum up their impact:

- More than €5 million were raised for conservation projects around the world.
- More than 140 conservation projects have received grants.
- New links have been established between EAZA and other conservation organizations, and between EAZA member institutions and individual conservation projects.
- Hundreds of millions of zoo and aquarium visitors have been informed about the importance of biodiversity conservation.

Ape conservation specifically was supported by the Bushmeat campaign (2000–2001) and the Ape Campaign (2010–2011). The first ever EAZA campaign raised the issue of the unsustainable and illegal hunting and trade of threatened wildlife – in particular the great apes. The main aims of the campaign were:

- To raise awareness concerning the impact that the hunting for wild meat has on great apes in Africa,
- To gather signatures for a petition urging leaders both in Europe and in Africa to address the crisis,
- And to raise funds to support great ape conservation projects.

**Table 7.1 Major campaigns 2000-2010**

Campaign	Active period	Year(s) running	Carnivore	Amphibian	Madagascar	Rhino	Shellshock	Tiger	Rainforest	Bushmeat
Aims										
Awareness		2	1	1	1	1	1	2	1	1
Fundraising		174	202	165	134	134	134	130	97	170
Petition		30	27	24	21	26	26	24	20	N/A
Zoo involvement		€257,405	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Promote public involvement		€243,664	€410,803	€450,635	€150,000	€250,058	€750,898	€750,898	€240,456	€100,000
Twinning EAZA with other partners		€412,265	€410,803	€605,000	€660,000	€494,291	€750,898	€750,898	€740,456	€100,000
Fundraising fund		1133	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,900,000
Promote ecotourism		8	6	20	22	12	9	10	3	
Political lobby at EU-level										
Collaboration with other professional communities										
Participation										
Fundraising										
Petition										
Projects										

Source: Author's elaboration based on EAZA (2019).



The campaign resulted in one of the largest petitions ever submitted to the European Parliament, with 1.9 million (!) signatures. In our EAZA report you can read:

*As a result of this petition and the debates it initiated, in 2004 the Parliament adopted a report that recognized the issue of bushmeat as important in relation to wildlife conservation, human food security and livelihoods, and human health. The impact of bush meat has now been included as one of the factors to be considered in assessing applications for EU funding. Considerable support in achieving this result came from the International Fund for Animal Welfare.*

*The EAZA Bushmeat Campaign, and in particular the adoption of the parliamentary resolution, played a key role in the granting of €3.4 million to UNEP-GRASP (Great Ape Survival Project). This ambitious project aims to lift the threat of extinction for great apes through intergovernmental dialogue and policy making, conservation planning initiatives, technical and scientific support to range state governments, and to raise fund and awareness in donor countries. (EAZA, 2010, p. 1)*

In the end, several projects were funded such as the Pan African Sanctuary Alliance, research into chimpanzees and gorillas in the Dja Faunal Reserve in Cameroon, and the Berggorilla & Regenwald Direkthilfe (B&RD) in DRC, which focuses on the survival of gorilla populations that are at risk.

The second Ape Campaign aimed to make a significant and lasting contribution to the continued survival of apes (great apes and gibbons) and their habitats. Another €580,000 were collected for great ape conservation projects.

Until now, the EAZA Ape Conservation Fund has supported 19 ape projects worldwide with a total of €426,531. Apart from supported gibbon and orangutan projects in Asia, chimpanzee projects in Africa, several gorilla projects in Cameroon, Congo, Nigeria, and the Central African Republic received significant funding.

These conservation funds are separate to the funding provided separately by EAZA Members, who contributed just under €26 million and 70,000 staff hours to field conservation projects in 2017 (EAZA, 2019a). It is worth remembering that the campaigns, while providing a lower level of funding for conservation, have aims and targets that do not relate directly to funding – as mentioned above, these include public education and mobilization, and lobbying by the zoo community as a united front.

## Summary/vision

A survey conducted by WAZA, in collaboration with national and regional associations, showed that annually more than 700 million people visit zoos and aquariums worldwide (Gusset & Dick, 2011). On the one hand, this figure may include multiple individual visits; on the other hand, this is most certainly an underestimate (WAZA, 2009) as still today new zoos and aquariums are established all around the globe. This number of visitors is probably unparalleled by any other group of conservation-oriented institutions. Gusset and Dick therefore state “The large number of visitors received and amount of conservation money spent suggest that the world zoo and aquarium community has the potential to play an important role in both environmental education and wildlife conservation” (2011, p. 568 cf. Dick & Gusset, 2010; cf. Zimmermann et al., 2007).

Moreover, zoos and aquariums attract a large variety of people. Humans, by nature, are interested in nature. These hundreds of millions of visits give zoos and aquariums significant influence, opportunity and responsibility, and because scientifically run zoological gardens are organized on a national, continental, and global level we, the Members and our associations, have the opportunity and the ability to improve our impact on mobilizing the public for legislative change.

The zoo and aquarium community reportedly spent about US\$350 million on wildlife conservation alone in 2008 (Gusset & Dick, 2011). Certainly, this figure was actually much higher as only about the half of the association Members submitted data. North America and Europe were the leading areas in spending money for conservation, but the other regions are moving in the same direction. The world zoo and aquarium community is one of the leading groups of conservation funding compared to the other major international conservation organizations.

Especially WAZA as well as the regional associations and their Members want to make a difference. Therefore, we intensively need to cooperate also with other partners such as the Botanical Gardens, Universities, NGOs, politicians, and all other players in this field. One goal WAZA has in mind is a World Species Congress. The IUCN and others have been thinking about it for years. What we want, in contrast to other political conferences, is to really make a difference. Therefore, we propose the creation of a movement that mobilizes the younger generation and uses their channels, such as social media, to strengthen our influence on society in terms of raising awareness of sustainable living and how it can be adopted by both individuals and by societies as a whole. This could be similar to what is

happening in Germany at the moment with the Friday demonstrations, in which pupils demonstrate against climate change. However, we must focus on achieving an actual outcome.

We (WAZA and its members) want to make a difference.

Finally, I would like to share with you the words of a former colleague who said: “If zoos did not exist today, we would have to invent them now!” As Pope Francis (2015) said in his *Laudato si’*:

*We cannot fail to praise the commitment of international agencies and civil society organizations which draw public attention to these issues and offer critical cooperation, employing legitimate means of pressure, to ensure that each government carries out its proper and inalienable responsibility to preserve its country’s environment and natural resources, without capitulating to spurious local or international interests.*

## Acknowledgments

I would like to thank Mr. David Williams-Mitchell from EAZA office for sharing the EAZA data with me, and my zoo educator Mrs. Ruth Dieckmann, my marketing officer Mr. Christoph Schütt and Mrs. Maerte Siemen, my secretary, for useful advice and support.

## Bibliography

- Bundesministerium für Bildung und Forschung, Referat Bildung in Regionen; Bildung für nachhaltige Entwicklung. (2017). *Nationaler Aktionsplan Bildung für nachhaltige Entwicklung: Der deutsche Beitrag zum UNESCO-Weltaktionsprogramm*. Last accessed on September 17, 2019, at [https://www.bne-portal.de/sites/default/files/downloads/publikationen/Nationaler\\_Aktionsplan\\_Bildung\\_f%C3%B-Cr\\_nachhaltige\\_Entwicklung\\_neu.pdf](https://www.bne-portal.de/sites/default/files/downloads/publikationen/Nationaler_Aktionsplan_Bildung_f%C3%B-Cr_nachhaltige_Entwicklung_neu.pdf)
- Dick, G., Gusset, M. (eds). (2010). *Building a future for wildlife: zoos and aquariums committed to biodiversity conservation*. WAZA Executive Office: Gland.
- Dioum, B. (1968). *Paper presented at the General Assembly of the International Union for the Conservation of Nature and Natural Resources*. New Delhi: Seattle Public Library Archive.
- EAZA (2010). *EAZA Bushmeat Campaign 2000-2001*. Last accessed on November 18, 2019, at <https://www.eaza.net/assets/Uploads/Campaign-factsheets/bushmeat0610.pdf>
- EAZA (2019). *EAZA campaigns*. Last accessed on November 18, 2019, at <https://www.eaza.net/conservation/campaigns/>
- EAZA (2019a). *European Parliament Elections 2019: EAZA Manifesto: Progressive zoos and aquariums working together for nature*. Last accessed on November 18, 2019 at <https://www.eaza.net/assets/Uploads/EAZA-Documents-Other/EAZAManifesto-WEB.pdf>
- Fraser, J., Wharton, D. (2007). The future of zoos: a new model for cultural institutions. *Curator*, 50, 41-54.
- GTT (2019). *About GTT: Aims and objectives*. Last accessed on September 13, 2019, at <https://greenteenteam.org/en/about-gtt/>

- Gusset, M., Dick, G. (2010). "Building a Future for Wildlife"? Evaluating the contribution of the world zoo and aquarium community to in situ conservation. *Int. Zoo Yearb*, 44, 183-191. doi:10.1111/j.1748-1090.2009.00101.x
- Gusset, M., Dick, G. (2011). The global reach of zoos and aquariums in visitor numbers and conservation expenditures. *Zoo Biol*, 30(5), 566-569. doi:10.1002/zoo.20369
- Luckert, T. (2008). *Naturschutz und Bildung für nachhaltige Entwicklung – Fokus: außerschulische Lernorte*. Bundesamt für Naturschutz: Bonn – Bad Godesberg.
- Miller, B., Conway, W., Reading, R.P., Wemmer, C., Wildt, D., Kleiman, D., Monfort, S., Rabinowitz, A., Armstrong, B., Hutchinson, M. (2004). Evaluating the conservation mission of zoos, aquariums, botanical gardens, and natural history museums. *Conserv Biol*, 18, 86-93.
- Pagel, T., Reckewitz, R., Spiess, W. (2010). *Kölner Zoo. Begeistert für Tiere*. Bachem-Verlag: Köln.
- Pagel, T., Spiess, W. (2011). Der Zoologische Garten Cöln eröffnet am 22. Juli 1860 – 150 Jahre Wildtierhaltung und -zucht. *Zoolog. Garten N.F*, 80, 117-202.
- Pagel, T. (2012). Zoologische Gärten und Artenschutz. *Bongo*, 43, 76-126.
- Pagel, T. (2016). Der gesetzliche Auftrag der Zoos. In Dollinger, P. (ed.). Akzeptanz und Relevanz der Zoologischen Gärten.7. Rigi-Symposium. Zoo Office Bern: Liebefeld-Bern, 45-46.
- Pagel, T. (2015). *Kölner Zoo – Wie geht das?* Bachem-Verlag: Köln.
- Pearson, E.L., Lowry, R., Dorrian, J., Litchfield, C.A. (2014). Evaluating the conservation impact of an innovative zoo-based educational campaign: 'Don't Palm Us Off' for orang-utan conservation. *Zoo Biol.*, 33(3), 184-196.
- Pope Francis (2015). *Encyclical letter: Laudato si' of the Holy Father Francis on care for our common home*. Vatican Press: Vatican City. Last accessed on September 26, 2019, at [http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco\\_20150524\\_enciclica-laudato-si\\_en.pdf](http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si_en.pdf)
- Rabb, G.B., Saunders, C.D. (2005). The future of zoos and aquariums: conservation and caring. *Int Zoo Yearb*, 39, 1-26.
- Van Schingen, M., Ha, Q.Q., Pham, C.T., Le, T.Q, Bonkowskis, M., Ziegler, T. (2016). Discovery of a new crocodile lizard population in Vietnam: Population trends, future prognoses and identification of key habitats for conservation. *Revue suisse de Zoologie* 123(2), 241-251. DOI: 10.5281/zenodo.155297
- WAZA. (2005). Building a future for wildlife: the world zoo and aquarium conservation strategy. WAZA Executive Office: Bern, Switzerland.
- WAZA. (2009). Turning the tide: a global aquarium strategy for conservation and sustainability. WAZA Executive Office: Bern, Switzerland.
- WAZA. (2018). WAZA Extends Sustainable Commitments Through Palm Oil Membership. WAZA News 2018/12/06. Last accessed on September 18, 2019, at <https://www.waza.org/news/waza-extends-sustainable-commitments-through-palm-oil-membership/>
- Zimmermann, A, Hatchwell, M., Dickie, L.A., WEST, C. (eds.). (2007). *Zoos in the 21st century: catalysts for conservation?* Cambridge University Press: Cambridge, UK.

## 8 ZOO-LED SCIENCE AND THE GLOBAL CONSERVATION OF SPECIES

MARK PILGRIM\*

During the last few decades, progressive European zoos that are part of the European Association of Zoos and Aquariums (EAZA) have evolved from menageries to conservation centres. Science and the application of scientific techniques has been key to this change. In this essay I will explain how zoos use a scientific approach to the global conservation of species using case studies. Four key topics are covered: 1) the ‘one plan approach’ using the Eastern black rhinoceros as the example, 2) the importance of working with local communities, 3) zoo science in conservation, and 4) using science to evaluate whether zoo visitors have a better understanding of biodiversity and positive actions they could take to protect it following a zoo visit.

The ‘One plan approach’ came from the International Union for the Conservation of Nature’s Conservation Planning Specialist Group (IUCN/CPSG). It is defined as: “Integrated species conservation planning that considers all populations of the species (inside and outside the natural range) under all conditions of management and engages all responsible parties and resources from the start of the conservation planning initiative” (Barongi *et al.*, 2015, p. 18). That means bringing together everyone interested in conserving a species and considers all of the populations of that species, those in the wild and those under human care.

The Eastern black rhinoceros is a good illustration of the how the one plan approach works. Since the 19th century the Eastern black rhino population as a whole has declined from several hundred thousand individuals to just over 5000 (Emslie *et al.*, 2016). The Eastern black rhino is listed as Critically Endangered on the IUCN Redlist (Emslie, 2011) and the rarest subspecies of black rhino with around 740 remaining in East Africa (Emslie *et al.*, 2016) and 92 in European Zoos (Biddle & Pilgrim, 2017). This zoo population is extremely important as it makes up 12% of the total global population. More than this, as these rhinos were collected and sent to Europe in the 1960s and 70s before the major poaching crisis, it is very

\* Vice-Chair EAZA and Chester Zoo CEO.

likely that the zoo population contains genes that no longer occur in the population in Africa.

To successfully manage this European Zoo population takes a great deal of cooperation between the zoos and some rules to follow to ensure the population achieves its goals. These goals are:

- 1) Ensure a healthy and sustainable population to fulfil the needs of EAZA zoos,
- 2) Manage the population to achieve a >5% growth rate per year. (This is based on the Kenyan Wildlife Service's growth target for free ranging black rhinos),
- 3) Maintain 90% gene diversity from 41 founders for 100 years,
- 4) Work closely with the African Rhino Specialist Group and Governments to make Eastern black rhino available for return to Africa to supplement populations where needed.

To be successful the EAZA Ex-situ Programme (EEP) is managed by a single coordinator who makes transfer and breeding recommendations for all the zoos holding this species. These recommendations are reviewed and approved by the Species Committee which is made up from a subset of the zoos keeping Black rhinos. Animals are not allowed to be bought or sold and the participating zoos must follow the recommendations. Excellent record keeping and scientific analysis of the studbook is essential, and zoos use computer software to do this. ZIMS is the global record keeping system, SPARKS is the studbook keeping system and PMx does the population analysis. PMx allows us to scientifically select individual males and females and test how genetically compatible they are. It helps us manage the population in a way that ensures we will lose as little as possible of the genetic diversity. Once we know which rhinos are best to breed with one another we need to keep them well and healthy. We also have to understand the best time to introduce them to each other. Black rhinos are solitary for most of the time. They gather together at night around waterholes and the females will only remain with a male when in oestrous as at this time the male is far less likely to be aggressive. Science also helps us here. Some zoos have endocrinology laboratories that can test the faeces or urine of animals to determine what stage of the oestrous cycle a female animal is in. It can also show a pregnancy but importantly it allows us to anticipate the time to introduce males and females together to have the best chance of them not fighting and injuring each other and a successful pregnancy.

The one plan approach also means that zoos are supporting wild Black rhino populations. Many zoos have been giving financial support to assist

with rhino monitoring and anti-poaching activities. These include funding additional front-line rangers and the equipment and infrastructure they need to work in the field. In Africa, the Eastern Black rhino now occurs in highly fragmented isolated populations. The science developed to manage zoo populations is now being applied to the small isolated populations in Kenya's National Parks.

It is of course also important for zoos to promote their work in the media, both to raise public awareness of the crisis facing biodiversity but also to show that there is hope of saving these magnificent animals and that zoos are part of the solution.

There is much more to what zoos do than breeding rare animals. Elephants, for instance, are incredibly popular animals in zoos. This gives zoos a unique opportunity to turn these positive feelings about an animal, into positive action to protect them. People are inspired by them. However, not all communities that come into close contact with them appreciate elephants. In Assam, northern India, the growing human population and its needs are squeezing the elephant population into ever-smaller areas. This leads to elephants leaving the forests and raiding the villagers' crops and damaging their property and injuring or even killing people. The communities retaliate with violence. Through support from our visitors and a Darwin Initiative grant, we work to help local communities mitigate this conflict. This requires understanding the species ecology and the communities' livelihoods.

This work requires three areas of focus: 1) interventions – to restore safety, 2) livelihoods – to offset economic risk, and 3) education – to build capacity for the future.

It is vitally important that intervention techniques are thoroughly researched and appropriate for the community. Assam is famed for growing hot chillies. Elephants will avoid the simple fences covered in chilli paste. The smoke from burning chillies also acts as a deterrent to elephants raiding crops. We have been working with local communities in Assam since 2005. Since that time, crop losses to elephants have been reduced by up to 78%. In the same timescale property damage from elephants has been reduced by up to 95% (Davies *et al.*, 2011). This is good for people and elephants. The next stage of the project is to share these techniques across a landscape of villages. In addition to helping to mitigate conflict with elephants, we have worked with local communities to develop alternative livelihoods. Zoo staff deliver training on running sustainable businesses, domestic animal husbandry workshops and plant care for farmers to increase their produce outputs in a sustainable way.

It is not only the large megafauna that zoos work to protect. The Golden mantella frog is only found in tiny patches of forest in Eastern Madagascar. It is about the size of your thumbnail. It is critically endangered due to habitat loss for expanding agricultural practices and uncontrolled collection of the Western pet trade.

To save any species from extinction it is crucial that the basic biology ecology of the species is well understood. Keeping the Golden mantella frog in our zoos allowed us to develop fluorescent markers without causing harm to the frog. By using this marking technique, we have been able to safely mark wild living frogs. This allows us to understand, for example, which of the forest ponds are most important for breeding, where the frogs go in the dry season, how long they live and so much more. This information allows us to set up and fund a conservation action plan for this species. We also train members of the local communities and staff from the Malagasy NGO that we partner with, called Madagaskara Vorkaji, to be able to continue this work of marking and studying this species. Taking our Golden mantella mascot into the local towns and villages causes a great deal of excitement, especially but not only from the children. Understanding this little frog and inspiring conservationists of the future is key to its long-term survival.

My last example of zoo-led science and the global conservation of species comes from the evaluation of zoo visitors. European zoos attract around 140 million visits a year (EAZA website, eaza.net). Many of these visitors come to the zoo for a day out, often with their children. They do not come primarily to be educated. A study was set out to test whether zoos, through the experiences and messages they give, can improve the general public's understanding of biodiversity and more importantly identify pro-biodiversity action that they can achieve at an individual level. This was a five-year research project (2012–2017) in collaboration with the World Association of Zoos and Aquariums, Warwick University, and the Convention of Biological Diversity (Moss *et al.*, 2014). It is the largest study of its kind in the literature. The overarching idea was to assess whether zoos and aquariums can contribute to global biodiversity targets that were adopted by the Convention on Biological Diversity (CBD) at its Nagoya conference. These targets are known as the Aichi targets of which there are 20. The target that this research aligns to is Aichi target 1 which states: “By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably” (CBD, n.d.). In both global surveys, we found small but significant differences between



pre- and post-visit measures in both of our independent variables, thus showing that indeed a visit to a zoo improved the understanding of biodiversity and how to take action to protect it.

## Bibliography

- Barongi, R., Fiskens, F.A., Parker, M. & Gusset, M. (eds.) 2015. *Committing to Conservation: The World Zoo and Aquarium Conservation Strategy*. WAZA Executive Office: Gland, Switzerland. Last accessed on November 18, 2019, at [https://www.waza.org/wp-content/uploads/2019/03/WAZA-Conservation-Strategy-2015\\_Portrait.pdf](https://www.waza.org/wp-content/uploads/2019/03/WAZA-Conservation-Strategy-2015_Portrait.pdf)
- Biddle, B. & Pilgrim, M.A. 2017. *Eastern Black Rhino EEP Annual Report 2017*. EAZA.
- CBD. n.d. *Quick guide to the Aichi Biodiversity Targets: Awareness increased*. Last accessed on November 11, 2019, at <https://www.cbd.int/doc/strategic-plan/targets/T1-quick-guide-en.pdf>
- Emslie, R. 2011. *Diceros bicornis ssp. michaeli*. The IUCN Red List of Threatened Species 2011: e.T39320A10198874. <http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T39320A10198874.en>
- Emslie, R.H., Milliken, T., Talukdar, B., Ellis, S., Adcock, K. & Knight, M.H. 2016. *African and Asian Rhinoceroses – Status, Conservation and Trade – A report from the IUCN Species Survival Commission (IUCN SSC) African Rhino Specialist Groups and Traffic to the CITES Secretariat pursuant to Resolution conf. 9.14 (Rev CoP15)*. Report to CITES 16th meeting Johannesburg 2016.
- Moss, A., Jenson, E. & Gusset, M. Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. 2014. *Conservation Biology*, Volume 29, Issue 2, 525-536.
- Wilson, S., Davies, T.E., Hazarika, N. & Zimmermann, A. (2013) *Understanding Patterns of Human-Elephant Conflict in Assam: An Analysis to Inform Mitigation Strategies*. *Oryx*.
- Davies, T.E., Wilson, S., Hazarika, N., Chakrabarty, J., Das, D., Hodgson, D.J. & Zimmermann, A. (2011), *Effectiveness of intervention methods against crop-raiding elephants*. *Conservation Letters*. 4: 346-354.

## 9 ZOOS: CONNECTING PEOPLE WITH NATURE AND WELLNESS BUILDING

MARÍA CLARA DOMÍNGUEZ VERNAZA\*

I live in one of the most biodiverse countries on the planet; our scientists have registered almost 63,000 species of life forms. We occupy the first place regarding the biodiversity of birds and orchids, the second place regarding plants, amphibians, butterflies and freshwater fish, the third regarding palms and reptiles and the fourth regarding the diversity of mammals.<sup>1</sup> In addition to this extraordinary biodiversity, more than 48 million people (75% of them living in cities)<sup>2</sup> comprising 87 different ethnic groups live in Colombia;<sup>3</sup> and we conserve 68 different living languages.<sup>4</sup> Colombia has two coasts on two oceans, the Atlantic and the Pacific, three Andean mountain ranges (west, central and eastern) cross it from south to north and tropical forests such as the Amazon and the biogeographic Choco, in which the rainiest place on earth ever registered is located. But, besides being a country where life flows in every corner, Colombia is also a country marked by 70 years of socio-environmental conflicts, related to the access, use and control of land and its resources, conflicts generated by drug trafficking, political violence, corruption, wildlife trafficking, and illegal mining. In those 70 years of conflict, Colombia has lost territory, has lost society and has lost biodiversity.

\* B.Sc., Fundación Zoológica de Cali, Colombia.

<sup>1</sup> These numbers are shared on the official website of SiB Colombia, the national network of open data on biodiversity. The report and its reference sources are available online at: <https://cifras.biodiversidad.co> (last accessed on October 31, 2019).

<sup>2</sup> Official DANE (statistical national department in Colombia) estimation from its 2018 national census. Available online at: <https://www.dane.gov.co/files/censo2018/infografias/info-CNPC-2018total-nal-colombia.pdf> (last accessed on October 31, 2019).

<sup>3</sup> Official DANE (statistical national department in Colombia) information from last public report on ethnic groups from its 2005 national census. Available online at: [https://www.dane.gov.co/files/censo2005/etnia/sys/colombia\\_nacion.pdf](https://www.dane.gov.co/files/censo2005/etnia/sys/colombia_nacion.pdf) (last accessed on October 31, 2019).

<sup>4</sup> Official Colombian Culture Ministry report for its native languages protection strategy. Available online at: [https://www.mincultura.gov.co/prensa/noticias/Documents/Poblaciones/DirPoblaciones\\_Atención\\_estatla\\_protección\\_lenguas\\_nativas.pdf](https://www.mincultura.gov.co/prensa/noticias/Documents/Poblaciones/DirPoblaciones_Atención_estatla_protección_lenguas_nativas.pdf) (last accessed on October 31, 2019).

Colombia is part of the Global South, the most recent denomination that international cooperation agencies use to refer to nations formerly known as developing countries, third-world countries or underdeveloped countries and that were mostly colonies of what is now considered the Global North. As in other countries of the Global South, in Colombia the contemporary challenges of humanity are faced with creativity and innovation, with a unique way of seeing the world, forged in the heat of multiple conflicts and contradictions.

### **An invitation to rethink the role of zoos and aquariums**

In the last 100 years, humanity has grown exponentially, and more than 70% of the people live in urban areas. The result is that today we have a planet with many people and a lack of citizenship. The global model is based on the perpetual growth, but the problem is not just that we grow, but how we grow. The current global growth model is based on three assumptions that affect the sustainability of the planet: produce more than what it requires, consume more than what it needs, and accumulated more than what it can to enjoy.

From our perspective, conservation is a social agreement to guarantee the conditions that make life possible in a specific territory. Consequently, the role of zoos, botanical gardens and natural history museums goes well beyond spreading knowledge about plants, animals or the natural world. We need these institutions to find their role within the social agreement we call conservation.

Today our society needs us to contribute to citizenship education, to the transformation of specific cultural practices related to forms and models of consumption, to the construction of local identities and to the engagement of citizens who understand the natural world in which they live. We are called to become welfare promoters for both humans' communities and wildlife. Our role is not to sell tickets to see animals. Our "Role" is to be platforms for people to create experiences that they never forget, that transform their lives such that they decide to assume sustainable life practices based on respect for life in all its dimensions.

Today, zoos, aquariums and natural history museums have become unique platforms for contact with natural and cultural heritage and the understanding of issues that affect the sustainability of the planet.

Thereby, zoos and aquariums have three big advantages that put them in a unique situation: First, they are mostly NGOs, but also belong to a productive sector. Second, they can influence the consumption habits of

millions of people who visit them each year and who represents 10% of the entire world population. Third, they can influence decision makers, promote solid alliances with authorities, political and scientific leaders and conservation NGOs, positioning issues of interest for sustainability and the transformation of the society-nature relationship as part of the public opinion.

The contribution to society does neither depend on the money that organizations have, nor on their size, nor on the number of animals or plants that are under their care; it depends fundamentally on the purposes of their actions, the coherence of their management and the integration with the community to which they belong.

### **Zoos and aquariums as wellness promoters**

Organizations such as zoos, aquariums and natural history museums constitute a powerful engine to forge new values in local societies. The road to sustainability implies acting to stop the “vortex” of the infinite growth, excessive accumulation and assumed happiness based on consumption. Procuring the wellbeing for human communities, wildlife and ecosystems, implies a development based on the principle of equity and the reduction of inequalities.

Facing inequalities implies to propose and promote a new culture of consumption, of technology and reasoning in current societies, where development is no longer measured by the quantity of wealth generated and accumulated, but by the wellbeing that it provides to society and the ecosystems that sustain different life expressions on the planet.

We need more critical societies that question their lifestyle and development model, more creative societies capable of inventing new possible futures for life on this planet, and more careful societies that reward collective achievements over personal successes, capable to reach agreements to face and overcome inequalities and inequities.

Zoos and aquariums are called to be powerful leaders and society allies for the reduction of inequalities. Each institution must be concerned with identifying, knowing and understanding the critical issues related to the generation of inequalities in the local society, in order to articulate actions aimed to confront and reduce these inequalities: Facilitating access to parks for vulnerable populations, taking care of a better education for all sectors of the population, promoting respect and conservation of natural and cultural heritage as a collective good, making alliances with NGOs and government agencies to increase the positive impact of your actions.

Responsible for caring and fostering welfare of wildlife, which is part of the collective natural heritage, zoological institutions must be organizations characterized by a transparent management systems that demonstrates an intelligent use of institutional resources and the commitment to the fulfillment – without exceptions – of human rights, environmental, laboral and tax laws, and other rules related to taxation and the protection of social funds in each country. In so doing, they must, in addition, ensure the promotion of values related to the care and appropriate use of public heritage in terms of collective wellbeing, thus seeking an equitable articulation of the society and nature interest.

Many of the traditional approaches to nature conservation have had adverse effects on vulnerable populations, limiting their access to biological resources and services that the ecosystems provide and that they need for their sustenance. All conservation programs should be an opportunity to rebuild the relationship between society and nature, promoting better practices in local communities and helping to ensure the conditions and circumstances that make life viable in a territory. Conservation programs should establish mechanisms to confront and transform the unequal distribution of space, resources, and power; moreover, they should determine indicators measuring social equity-building and thus provide evidence on how the costs and benefits of conservation are shared in a fair and equitable way, in accordance with socioeconomic, gender, ethnic and generational considerations.

Zoos and aquariums must add to the IUCN guidelines expressed in the “Policy on Social Equity in Conservation and Sustainable Use of Natural Resources”,<sup>5</sup> that promote fighting poverty through undertaking conservation actions. IUCN recognizes the important role of conservation organizations for poverty reduction and identifies the need to prioritize the relationship between development and the conservation of biodiversity in the bilateral agendas, thereby inviting all organizations concerned with environmental issues to commit to joint actions to foster poverty reduction, sustainable development, the improvement of the quality of life of populations and the conservation of biodiversity, thus considering that social equity cannot exist without the promotion and protection of human rights.

The nature of the fauna populations that we host makes us centers of knowledge dissemination regarding “diversity”. The varied character-

<sup>5</sup> This policy was adopted at the IUCN Council Meeting in February 2000. The statement is available online at [http://cmsdata.iucn.org/downloads/sp\\_equity\\_policy.pdf](http://cmsdata.iucn.org/downloads/sp_equity_policy.pdf) (last accessed on October 18, 2019).

istics of our visitors, their different ages and interests, give us the chance of meeting territories of “diversity”. Our organizational structures and forms of management should also reflect that “diversity” is a highly appreciated value. We must actively work to build healthy organizations that are promoters of wellbeing. Internal relations based on good treatment, non-discrimination and equal opportunities are necessarily reflected in better practices of animal care, a more enjoyable experience for visitors, and sound attention paid to suppliers as well as further benefits in other areas that constitute the organization. In addition, the diversity of thought in the workplace promotes innovation and the social, environmental and economic profitability of the organization.

### **Key actors in achieving the Sustainable Development Goals**

The World Association of Zoos and Aquariums (WAZA) actively works to promote the adoption of the Sustainable Development Goals (SDGs) as guidelines for the management of zoological institutions. The SDGs are a shared, inclusive, and global agenda which seeks to safeguard that nobody is left behind. They constitute a universal call for measures to end poverty, to protect the planet and to ensure that all people enjoy peace and prosperity. The SDGs carry a spirit of collaboration and pragmatism to choose the best options in order to improve life in a sustainable way. They provide clear guidelines and goals for their adoption by all countries, organizations and people, in accordance with their own priorities and the environmental world challenges.

Three levels of commitment are proposed, each one incorporating the previous ones:

Level I: To disseminate and communicate, inviting and motivating citizens to take action. Considering that zoos and aquariums are visited by all types of audiences, they constitute an extraordinary scenario to raise awareness of the SDGs, related accomplishments, ways of supporting the causes and, of course, highlighting the connection between the SDGs and conservation.

Level II: Sustainability and corporate social responsibility. Incorporating SDGs within the strategic direction. Around the world, companies of different sizes, strengths and financial capacities are aware of the need to make their operation sustainable, of the opportunities presented in this changing scenario for the development of new ways of doing business; in this way, they make explicit their commitment to the SDGs, generating value for their consumers and customers and including it in their management and

corporate impact reports. Zoos and aquariums, considered as businesses, can do the same. This level II is where the “sustainability” of the operation is located, in terms of being friendly to the environment (energy use, water management, waste management, use of plastics, etc.). Zoos and Aquariums are obliged, for the sake of coherence, to manage and minimize their negative impact on their environment.

Level III: To be living examples of sustainable development. This level means going beyond telling others to do something (Level I), allocating resources to support initiatives of other organizations and thus not negatively impact the environment (Level II); it is about incorporating the SDGs into their own agenda and identity. It is the highest level of coherence, bringing the yearnings of the 17 Goals and the general idea of sustainable development to the daily operation in the zoo or aquarium. The challenge is that each of the decisions, policies, and values can explicitly connect with the SDGs, so that there is gender equity, transparency, justice, peace, health, promotion of education, prosperity, etc.

In conclusion, it is pertinent to highlight that we can all contribute to the SDGs and there is only one way to do it right. Everyone must do it according to their conditions, restrictions, possibilities and interests. No zoo or aquarium in the world should “be left behind” in the implementation of the SDGs. The relationships between the SDGs and the conservation of species and habitats must be made explicit. Global South institutions must demonstrate an adequate and important participation in this process. Each institution should establish its own path based on an analysis of its context, circumstances, needs, and opportunities. Each institution must analyze the SDGs and establish the structure of relationships deemed most relevant to their current situation and their longing for the future. It is not possible to account for all SDGs in the same way or intensity; however, given their interrelation, working directly on implementing one of them can have an impact on the others.

As Mae West said: “You only live once, but if you do it right, once is enough”.<sup>6</sup>

<sup>6</sup> Although Mae West – renowned American actress between 1920s and 40s – popularized this and other aphorisms, it is a variation from the popular saying *you only live once*.

- ▶ **IV. Lessons and Insights from Botanical Gardens' Research and Outreach**





## PLANT CONSERVATION: CHALLENGES AND OPPORTUNITIES

PETER RAVEN\*

As the papers presented in this collection confirm, plants present unique opportunities for conservation. They are rather easily grown in areas with an appropriate climate; moreover, the seeds of most species can be stored for decades, sometimes centuries, in seed banks or growth chambers. But what then? Their successful long-term conservation demands that suitable conditions for their growth continue to exist and eventually will be restored on our planet. In allegorical terms, the Ark is a vessel described in the Bible (Genesis, Chapter 6) as being 134 meters long, 13.4 meters wide, and 9 meters tall, thus with plenty of room for all domestic animals and a few others, but of very limited capacity considering all the species that live on Earth – very few of them could be accommodated. And after 150 days, the waters receded and the Ark came to rest on land.

I use the details of this Biblical tale because we all need to ask what are the limits of what living things we can save with our capacity, and also because we need to ask, having saved them, when and how will our “waters” finally recede?

In the roughly 11,000 years since our ancestors learned how to cultivate crops and domesticate animals for food and other purposes, our numbers have grown from approximately one million people, with only 100,000 of them in Europe, to the current 7.7 billion people, 500 million of us in Europe.<sup>1</sup> In other words, a multiplication by 7,700 has occurred in our population in less than 400 generations! And we are currently estimated to be consuming approximately 1.75 times the sustainable capacity available on Earth, so that last year, by August 1, we had used up all the Earth’s ecosystems could regenerate in the entire year, living on depletion for the rest of the year.<sup>2</sup> This year, the date was even earlier: on July 29. And our population is projected to grow by an additional 2.3 billion within just 30 years, that is, by mid-century.<sup>3</sup> At present, some 795 million people are estimated not to

\* PAS Academician.

<sup>1</sup> [www.prb.org](http://www.prb.org)

<sup>2</sup> [www.footprintnetwork.org](http://www.footprintnetwork.org) / [www.overshootday.org](http://www.overshootday.org)

<sup>3</sup> [www.prb.org](http://www.prb.org)

get enough food regularly to lead an active life, half of whom lack sufficient amounts of at least one essential Nutrient.<sup>4</sup> The inequality between nations and their rates of consumption is growing,<sup>5</sup> and some 40% of Earth's ice-free land surface is already occupied by some form of agriculture (including grazing).<sup>6</sup> Much of the remaining 60% consists of cities or other forms of human encroachment. Within the remainder, the area occupied by natural vegetation is much smaller than it once was, and it is shrinking rapidly.

Over time, inequality within and between nations has also become a major problem. Thus, eight individuals have been estimated by British charity Oxfam to possess as much wealth as the world's poorest 3.6 billion people, with nationalism and selfishness continuing to grow steadily when they clearly need to recede if we are ever going to be able to attain global sustainability. Although climate change is seen as a global concern, the efforts mounted so far have not reached a level at which the ongoing rise in temperature would ever be stabilized. In addition, the importance of biodiversity loss, and with it the disruption of conditions that alone make our lives on this planet possible, is a concern for relatively few people throughout the world.

Against this background, what are the future prospects for plants? Charismatic megafauna and a few butterflies, like the monarch butterfly (*Danaus plexippus*) charm us and capture most of the conservation headlines. Nevertheless, we are entirely dependent on plants for our food, many medicines, building materials, and a number of other products. We also depend on them collectively to maintain the composition of our atmosphere, to control erosion, precipitation patterns and other aspects of climate, and for the beauty and interest that they add to our lives, they have thus far not received the conservation attention they deserve. Overall, there are estimated to be 390,000 to 400,000 validly named species of vascular plants (lycops, ferns, gymnosperms, and flowering plants; Chapman, 2009; Joppa, Roberts, & Pimm, 2010; Kew, 2017; Pimm & Raven, 2017), with perhaps as many as another 70,000 awaiting naming and in some cases even discovery. For eukaryotic organisms overall, estimates indicate that there are at least 10–12 million species, with fewer than 2 million of them having been recognized up to today and assigned scientific names. Considering this, vascular plants are relatively well known; but the situation becomes even

<sup>4</sup> [www.wpf.org/hunger/stats](http://www.wpf.org/hunger/stats)

<sup>5</sup> [www.gfn.org](http://www.gfn.org)

<sup>6</sup> [www.nationalgeographic.com/news/2005/12/agriculture-food-crops-land](http://www.nationalgeographic.com/news/2005/12/agriculture-food-crops-land)

more challenging when we consider how few of them, perhaps 50,000 or so, can be considered to be understood in any reasonable level of detail.

How many vascular plant species are estimated to be facing extinction over the next several decades? At least 600 species have become extinct over the past 260 years (Humphreys et al., 2019), and that estimate is very likely to be too low. During the next several decades, there seems to be justification for assuming that 20% of the total could disappear, with perhaps twice that fraction or even more in danger of being lost by the end of the century (Pimm et al., 2014; Kew, 2016). Ceballos et al. (2015) have demonstrated convincingly for the areas they have surveyed, such as Mexico, that some 60% of the populations of vertebrates have become extinct since 1950. The situation for plants seems to be similar, indicating that extinction may be proceeding far more rapidly than would be deduced from measuring species extinctions alone (Raven, in press). At any rate, the growth in human populations, the expansion and intensification of our agricultural activities, ongoing climate change, and the seemingly unrelenting demand for ever-higher levels of consumption, including the growing commercial exploitation of many plant species (Kew, 2016, 2017) will make it very difficult to preserve very much of the existing tropical forests until the end of this century. Specifically, conservation schemes that assume a forthcoming human acceptance of our common need for global stability strong enough for us to give up our nationalism and personal greed in the common interest are difficult to accept as realistic. We must beware of the distraction that they may bring us along with their valuable inspiration to do better. In a way, some such schemes might be said to be in essence “pipe dreams” that could be realized fully only within the parameters of a relatively stable and socially just world.

In a general sense, the recent publication of a comprehensive biodiversity conservation effort, Global Deal for Nature (GDN; Dinerstein et al., 2019), intended to match the existing Paris Climate Accord, represents an impressive accomplishment. On the other hand, the PCA not yet caused nations overall to come near what would be needed to achieve its targets, despite the fact that a much higher proportion of people, perhaps two-thirds of us in the U.S., are concerned with climate change than with biodiversity loss. Any such treaty can only become effective enough when the underlying causes of the problem being addressed are recognized as real barriers to its realization. These obstacles include continued population growth, ever-growing consumption levels, nationalism, and human greed, all formidable obstacles as we attempt to save our living planet.

The Global Strategy for Plant Conservation (GSPC) is dedicated to saving the world's plant species and aligned with the U.N. Sustainable Development Goals, but even they must operate within the bounds set by human nature. It is certainly a good thing to set aspirational goals, but we shall clearly be able to achieve only limited success in attaining them until we fully address the moral underpinnings that alone can make their attainment possible. I hope this Vatican conference and the underlying values expressed so well in the Papal Encyclical *Laudato si'* might help to open our eyes to the reality within the bounds of which we must operate.

What can we do to prepare our dispersed, contemporary “Noah’s Ark” for the human-driven deluge that I have just described? The world’s nearly 3,000 botanical gardens presently have in cultivation more than 115,000 species of vascular plants, more than a quarter of the known total. Botanic Gardens Conservation International (BGCI), together with its regional and national partners, is prioritizing the collection and conservation of rare and threatened plant species by employing a cost effective, rational sharing of responsibilities, skills and knowledge (Smith, 2016; this symposium). For example, there are very significant living collections held in particular places, such as the collections of palms and cycads at the Jardín Botánico de Quindío in Colombia, on which Alberto Gómez reports here, and the Montgomery Foundation Gardens in Coral Gables, Florida.

In general, botanical gardens are just starting to take into account the serious challenges they will face in maintaining these collections as the global climate continues to warm steadily, altering growing conditions in their gardens progressively and significantly. In this respect, seed banks and frozen tissue cultures may afford the better hope for preserving the rich treasure of species that still exists today. For many plant groups however, the palms and cycads just mentioned among them, protocols have not sufficiently been worked out for seed preservation; the absence of such protocols poses a real obstacle to the conservation of many plants. Coordinating centers such as the Center for Plant Conservation in the U.S., represented here by John Clark; the U.S. Department of Agriculture, represented by Chris Williams; the Australian National Botanical Garden and seed collection; and the Kunming Institute for Botany, Chinese Academy of Sciences, are doing good jobs in preserving the floras of their respective areas of focus.

On a regional basis, we can offer a few more detailed estimates. Australia is home to about 26,000 species, about 90% of them described scientifically. Damian Wrigley (pers. comm.) estimates that the Australian Seed Banks

Partnership presently holds about 13,200 of the total species and about half of the estimated 4,000 threatened species of plants in seed banks (also see Australian Seed Bank Partnership, 2017), with a strong continuing effort to increase the sizes of many of the samples and add the missing species.

Roy Gereau (pers. comm.) has estimated that continental Africa (including Madagascar) is home to about 63,500 species of vascular plants. In North and South America, there are some 124,993 known species of vascular plants, as of December 2017 (Ulloa et al., 2017). The total restricted to the North American continent is about 42,941, with perhaps 12,000 found only north of Mexico. This indicates that a total of about 115,000 species were known from Mexico southward in the Western Hemisphere in the New World in 2017, but some 3,800 additional species have been described from or detected in this area (biogeographically roughly comparable to Africa and Madagascar) since the checklist was compiled.

Comparing these regions, the area from Mexico southward in the Americas, which has an area of about 18 million square kilometers, has about 120,000 species of vascular plants known at present, whereas Africa, with a total area of more than 30 million square kilometers, is home to only about 60,000 species. Compounding the difference between the two tropical areas, the number of recognized vascular plant species in Latin America is growing rapidly, while the number in Africa, where the floras are much better known, is growing much more slowly (R. Gereau estimates possibly an eventual 5% increase in the African total). Before such accurate comparisons were possible, we enumerated some of the likely reasons for this extraordinary difference (Raven and Axelrod, 1974), including the post-mid-Miocene (15 my) elevation of 2500 meters in eastern Africa; the Andes, rising in the past several million years, protecting much of America's forested area from drying winds from the west while confining summer-dry (Mediterranean climate) vegetation of much more recent origin to a small area; and most of South America remaining at relatively low elevations throughout the Tertiary. About a third of Africa is desert, but less than 10% of the smaller area of the Americas from Mexico southward is also desert.

I estimate that Africa, Australia, Europe and Russia, North and South America have a known total of about 250,000 known vascular plant species, with China and Japan probably adding something like 20,000 species not found to their north or south, tropical Asia should be home to about 130,000 known species, with many more still to be discovered there.

Paul Smith (pers. comm.) has estimated that about 42% of the IUCN-denominated threatened species of plants may already be preserved

in seed banks. This proportion would obviously be much lower if we had discovered all species already and knew the rare and tropical ones as well as we do those growing near most of the world's botanical centers. Kew's Millennium Seed Bank includes seed samples of nearly 40,000 species of vascular plants, a number that is increasing steadily. Overall, seed banks and tissue culture centers already include more than 60,000 species of vascular plants, but clearly not all of them are being held under optimum conditions (Paul Smith, pers. comm.). This still represents a relatively small proportion of the world's species, and we much certainly do what we can to increase both the number of species represented and the dependability of their storage conditions. Unfortunately, we cannot really foresee when the "waters may fall" and there will be good opportunities to re-establish many of these in nature from material that we have preserved in our own modern "Noah's arks".

A great deal of experimentation is going on with re-establishing plant species in nature, where they should in principle be able to maintain themselves without further human interference. Both Volis (2019; this symposium) and Hitchcock (this symposium) provide good examples of how that can properly be done. As long as we continue to destroy large areas of natural vegetation for our growing needs; to allow native plants to be swamped by invasive exotics; the gathering of native species for commercial purposes; and the continuing warming of the climate, saving a large proportion of the existing vegetation will be impossible. As the decades pass, we may find global warming to be an irresistible force towards extinction, discussed exceptionally well in a recent book edited by Lovejoy and Hannah (2019). Climate change threatens many plant communities with extinction over the next few decades. For example, the rich arrays of endemic vascular plants along the southern edges of Africa and Australia; these plants and the animals that occur with them will literally have no place to go if their habitats warm to temperature levels at which they cannot survive. The same is obviously true of plants that grow at high elevations on mountains, or even in montane areas such as the biologically rich cloud forests of the tropics, where an entire climate regime is in the process of being lost (Janzen & Hallwachs, 2019; Helmer et al., 2019). Species can in principle be reestablished at higher latitudes and altitudes than those that prevail now in the areas where they occur naturally (e.g., *Torreya floridana*), but climate stability is ultimately required for them to persist even there.

The development of strategies for finding and if possible preserving plant species while they still exist would be extremely important if we are

to do the best we can in this situation. As we have pointed out (Pimm et al., 2014), the species most likely to become extinct are by definition the rare ones, and most of the undescribed species are relatively rare. Probably a majority of plant species known to be of conservation concern grow in “hot spots”, originally defined by Myers et al. (2000) as areas that were 70% disturbed by human activities and having at least 2,000 endemic vascular plant species; so much of our conservation attention ought to be concentrated in these areas.

Hot spots of particular concern are those areas of the world with a Mediterranean (summer dry) climate, communities no more than a few million years of age, the summer drought having been formed as a result of the prevailing westerly winds passing over cold offshore currents (Ice age origin) on warmer lands in summer. If, as seems likely in the face of ongoing global warming, those currents warm, the pattern of summer drought will cease, and most of the thousands of plant species that are endemic in these areas and of relatively recent origin will then be driven to extinction. That would argue for a strong and urgent concentration of conservation efforts in and around California, central Chile, southwestern and southern Australia, the Cape Region of South Africa, and in the Mediterranean region itself, as well as along the southern edges of Australia and Africa for reasons already mentioned. Everywhere, though climates are changing, with the tropics expanding at about 30 miles per decade and the Globe’s wheat belts pushing poleward at up to 160 miles per decade (summary by Jones, 2019). Beach and other coastal plants may be in special danger of extinction, with a sea level rise of more than 2 meters projected in current scenarios (Bamber et al., 2019).

What about the tropics themselves? About a quarter of all tropical low-land forests have been destroyed since the Convention on Biological Diversity (CBD) came into effect in 1993 – within just 26 years! These forests are the most poorly known of all regions biologically, and the home of at least two thirds of the world’s species of vascular plants, probably 300,000 species overall. Specific areas of the tropics will be the world’s richest in species of most groups of organisms, certainly including flowering plants, and they are also the most poorly known and the most poorly represented in botanical gardens and seed banks. We provided some details for the individual countries in our collection of essays, “Voices from the Tropics” (Sodhi, Gibson, & Raven, eds., 2013), showing that the forests of some of the richest and most poorly known areas, such as New Guinea, are likely to be largely destroyed by mid-century. As if that were not bad enough news, the



destruction of these forests will clearly increase the rate of warming everywhere on our planet, and is likely make the destruction of all ecosystems even more rapid. Relationships of this kind present us with a real sense of urgency, since there will be only so much we can learn during the time we have remaining, and suggest that those in a position to do something about the matter ought to develop some joint goals and pursue them vigorously. There will, unfortunately, be no second chances.

An especially telling demonstration of how little we actually know is demonstrated by the work of Tetsukazu Yahara of Kyushu University. Using molecular comparisons, Yahara and his colleagues have discovered many dozens of previously undetected species of Southeast Asian trees and shrubs, species which when detected usually exhibit clear morphological differences. Especially in families like Lauraceae, whose inconspicuous, usually yellowish-green flowers last only a very few weeks, the discoveries have been impressive in scope, indicating that many more species exist in the tropics that we have yet recorded scientifically.

To mention two additional non-woody families, André Schuiteman (pers. comm.) estimates that there are some 25,640 valid species of orchids (756 genera), with perhaps as many as 4,000 species remaining to be described. Thomas Croat (pers. comm.) estimates that there are 3,645 accepted species of Araceae (144 genera), but he has roughly 1,600 additional undescribed species in his collection. This total of about 4,250 species already in herbaria and the ongoing extraordinary discoveries that are still being made, especially in the Neotropics, indicates that our knowledge is very incomplete. Ultimately, as many as 10,000 species or even more may be found in this family if we can explore the relevant tropical areas while there is still time to do so.

The future of tropical forests is unfortunately unclear; although there are many plans and suggestions of how they might be conserved at least in part, they intrinsically all count on a degree of sharing between people within and between countries that is almost beyond imagining. In the absence of such a development, the prospect of many countries falling into what we have defined as an “Ecological Poverty Trap”, a point at which their already very low ability to consume is ever more limited by declining biocapacity per person, while also faced with too low income to afford imports from other places. One effect is the inevitable depletion of their natural assets. A rapidly growing number of countries are already in this situation or approaching it at a time when they have exhausted their resources and have no options but to sell what they can to other countries

in order to survive (Wackernagel et al., 2019). Such countries will not be able to pursue schemes for the conservation of their biological riches by following plans and suggestions developed by the wealthy unless we can reverse our natural selfishness, recognize the worth of their people, and collaborate with them fully. Extinction and exhaustion of resources are proceeding rapidly, and one may reasonably wonder about the likelihood of those profound moral changes taking place while there is still time to accomplish something significant together.

This flood of changes has already begun, and extinction is already proceeding at something like 1,000 times the background rate. The pace of this destructive process has increased to such a degree that many biologists have concluded – notably Ceballos, Ehrlich, & Dirzo (2017) – that we have already entered the world’s Sixth Major Extinction Event, the first one since the end of the Cretaceous Period 66 million years ago – the time when the last dinosaurs became extinct and the character of life on Earth was permanently altered. In any case, we are very close! Carrying the analogy of this symposium further, it would be almost as if Noah and his sons were starting to build their Ark while the waters were already rising around them and the animals they wanted to save swimming or clustered on small islands. Everything about our situation now calls for collaboration, with the development and pursuit of appropriate collective goals, ultimately demanding recognition by our governments of the madness of maintaining their selfishness in the face of the disasters we are facing together. Anything less would not result in saving the biological richness with which our world has been endowed, and indeed would not be worth of us. As our colleague Dan Janzen put it recently when conversing on this issue, “If we don’t save it now, we can’t save it later”. It is time to get even busier, more focused, and more collective in our thoughts. As one of its organizers, I hope that this symposium will help us attain that necessary goal and look forward to the fine presentations that will now be provided by our botanical colleagues.

## Bibliography

- Australian Seed Bank Partnership. 2017. Safeguarding Australia’s Flora through a national network of native plant seed banks. Australian Seed Bank Partnership, Australian National Botanic Gardens, Canberra.
- Bamber, J.L., M. Oppenheimer, R.E. Kopp, W.P. Aspinall, & R.M. Cooke. 2019. Ice sheet contributions to future sea-level rise from structured expert judgment. *Proc. Natl. Acad. Sci. U.S.A.* 116: 11195–11200.
- Ceballos, G., P.R. Ehrlich, A.D. Baranosky, A. García, R.M. Pringle, & T.M. Palmer. 2015. Accelerated human-in-

- duced species loss: Entering the sixth mass extinction. *Science Advances* 1(5): e1400253. <https://doi.org/10.1126/sciadv.1400253>
- Ceballos, G., P.R. Ehrlich, & R. Dirzo. 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proc. Natl. Academy of Sciences U.S.* 114: 6089–6096. <https://doi.org/10.1073/pnas.1704949114>
- Chapman, A.D. 2009. Numbers of living species in Australia and the World. *Australian Biological Resources Study*, Canberra.
- Dinerstein, E. et al. (19 authors total). 2019. A global deal for nature: Guiding principles, milestones, and targets. *Science Advances* 5(4): eaaw2869. <https://doi.org/10.1126/sciadv.aaw2869>
- Helmer, E.H., E.A. Gerson, L.S. Baggett, B.J. Bird, T.S. Ruzycski, & S.M. Vogtesser. 2019. Neotropical cloud forests and páramo to contract and dry from declines in cloud immersion and frost. *PLoS ONE* 14(4): e0213155. <https://doi.org/10.1371/journal.pone.0213155>
- Humphreys, A.M., R. Govaerts, S.Z. Ficinski, E.N. Lughadha, & M.S. Vorontsova. 2019. Global dataset shows geography and life form predict modern plant extinction and rediscovery. *Nature Ecology & Evolution* 3: 1043–1047. <https://doi.org/10.1038/s41559-019-0906-2>
- Janzen, D.H. & W. Hallwachs. 2019. Perspective: Where might be many tropical insects? *Biological Conservation* 233: 102–108. <https://doi.org/10.1016/j.biocon.2019.02.030>
- Jones, H. 2018. Redrawing the map: How the world's climate zones are shifting. *YaleEnvironment360*, October 25, 2018, p. 1–6.
- Joppa, L.N., D.L. Roberts & S.L. Pimm. 2010. How many species of flowering plants are there? *Proc. R. Soc B.* 278: 554–559. Published online 7 July 2010. <http://dx.doi.org/10.1098/rspb.2010.1004>
- Kew. 2016. *State of the world's plants 2016*. Royal Botanic Gardens, Kew, Richmond, U.K.
- Kew. 2017. *State of the world's plants 2017*. Royal Botanic Gardens, Kew, Richmond, U.K.
- Lovejoy, T.E. & L. Hannah. 2019. *Biodiversity and Climate Change*. Yale University Press, New Haven.
- Pimm, S.L., C.N. Jenkins, R. Abell, T.M. Brooks, J.L. Gittleman, L.N. Joppa, P.H. Raven, C.M. Roberts, & J.O. Sexton. 2014. The biodiversity of species and their rates of extinction, distribution, and protection. *Science* 344: 987. <http://dx.doi.org/10.1126/science.1246752>
- Pimm, S.L. & Raven, P.H. 2017. The fate of the world's plants. *Trends in Ecology & Evolution* 32: 317–320. <https://doi.org/10.1016/j.tree.2017.02.014>
- Raven, P.H. (in press). Biological extinction and climate change. In Al Delaimy, W.K., V. Ramanathan & M. Sánchez S. (eds.), 2019. *Health of People, Health of Planet and Our Responsibility. Climate Change, Air Pollution and Health*. Springer Verlag.
- Raven, P.H. & Axelrod, D.I. 1974. Angiosperm biogeography and past continental movements. *Ann. Missouri Bot. Gard.* 61: 539–673. <https://doi.org/10.2307/2395021>
- Smith, P.P. 2016. Building a Global System for the Conservation of all Plant Diversity: A Vision for Botanic Gardens and for Botanic Gardens Conservation International. *Sibbaldia* 14: 5–13. <https://doi.org/10.23823/Sibbaldia/2016.208>
- Sodhi, N.S., L. Gibson & P.H. Raven (eds.). 2013. *Conservation Biology. Voices from the Tropics*. xxiv + 264 p. Wiley Blackwell, Oxford.
- Ulloa, C. et al. 2017. An integrated assessment of the vascular plant species of the Americas. *Science* 358: 1614–

1617. <https://doi.org/10.1126/science.aao0398>
- Volis, S. 2019. *Plant Conservation: The Role of Habitat Restoration*. Cambridge University Press, Cambridge, p. xvi + 480.
- Wackernagel, M., D. Lin, M. Evans, L. Hanscom, & P.H. Raven. 2019. Defying the Footprint Oracle: Implications of country resource trends. *Sustainability*, 11(7): 2164. <https://doi.org/10.3390/su11072164>

## **THE CENTER FOR PLANT CONSERVATION MODEL TO URGENTLY AND EFFECTIVELY CONSERVE NORTH AMERICAN PLANTS**

JOHN R. CLARK\*

### **Abstract**

With an estimated 4,400 kinds of plants facing extinction in the US and Canada, fully one quarter of the native plants of the two countries, there is an urgent need to save these irreplaceable species before it is too late. The Center for Plant Conservation (CPC) was founded in 1984 to address this challenge, with the guiding principal that plant conservation experts must come together to make a meaningful difference in preserving plant diversity for future generations. CPC Participating Institutions, a network of now 60 of the world's leading plant conservation organizations, use cutting-edge methods and the best science available to save plants from extinction. CPC's mission is simple and proven: to ensure stewardship of imperiled native plants. To do this, CPC implements the following tested and effective model: 1) advance science-based best practices in plant conservation through our network of conservation partners known as Participating Institutions, 2) apply these practices to save plants from extinction in the US and Canada as part of the CPC National Collection of Endangered Plants, and 3) share best practices with conservationists all over the world and advocate for plants and their value to humankind. To date, over 1,500 kinds of imperiled plants are now secured from extinction in the CPC National Collection, representing over one third of the US-Canada imperiled species found there. Current efforts are focused on advancing the science and methods needed to ensure the remaining two thirds are similarly conserved. To this end, CPC routinely compiles and shares conservation guidelines, including a completely revised version this year. These guidelines are used by plant conservationists not only in the US and Canada but also by those working around the world to save plants. Additionally, the CPC team is now focused on creating better means to bridge the gap between scientific advancements and applied conservation outcomes. This

\* Ph.D., President and CEO, Center for Plant Conservation, 15600 San Pasqual Valley Rd., Escondido, CA 92026, USA; [jclark@saveplants.org](mailto:jclark@saveplants.org); 760.291.5486.

challenge is being addressed through a new web-based data sharing and conservation information platform known as Plant Nucleus. Plant Nucleus is the redevelopment of CPC's website into a go-to online resource community where CPC partners engage to save plants from extinction.

## **Introduction**

From food to medicine, from clean air to clear water, to intrinsic beauty and the very landscape that covers our planet, plants define the human experience. Plants provide overwhelming benefit to the planet, regulating global water and air cycles, cleaning the soils, and shaping the environment in ways conducive to human health and longevity. Despite this indispensable and multifaceted role in our lives, plants are remarkably undervalued. Nothing accentuates this neglect more than the sheer number of plants that face extinction.

## **The value of plants**

It is widely known that plants provide an essential backbone of ecological support for our planet, maintaining the quality of life we enjoy today (see Raven, this volume; Smith, this volume). Plants clean Earth's air, water and soil and maintain global nutrient cycling, among many other benefits commonly referred to as ecosystem services (Ehrlich and Mooney, 1983). Plants are vital to fundamental aspects of these ecosystem services, and maintaining plant diversity is proven to positively enhance these services including provisioning of plant products, erosion control, invasion resistance, pest regulation, pathogen regulation and soil fertility regulation, in addition to the aforementioned services (Quijas et al., 2010). Plants thus directly affect overall human health and provide the foundation needed to mitigate the effects of a burgeoning human population with its increased land use and overall environmental degradation including climate change (Haines-Young & Potschin, 2010; Raven, this volume).

Further concerning quality of life, plants form the foundation of modern medicine and human nutrition. Plants have been a primary source of medicines since prehistory, a trend that continues extensively today (Petrovska, 2012). Even in this century, 11% of the ~250 essential drugs recommended by the World Health Organization are of flowering plant origin (Veeresham, 2012). Foods are also fundamentally plant based and even those that are animal in origin are inherently dependent on plants. Plant-based diets have been overwhelmingly proven to be both the healthiest for human consumption and beneficial to the environment, often eliminating

carbon loss and waste associated with animal-based diets (Spingmann et al., 2016). Numerous studies support plant-based diets as correlating strongly with a lower frequency of major illness in humans including cancer, heart disease and diabetes (Hever, 2016).

An increasingly recognized importance of plants is the intrinsic value they bring to our quality of life. Studies in recent decades illustrate well that nature, and in particular plants and plant-dominated landscapes, provide much needed health benefits (Keniger et al., 2013). Conversely, deprivation from natural environments has been shown to increase stress and related psychological and physical disorders, although research is ongoing (see Keniger et al., 2013). The effects of this deprivation are so profound that it has been given a formal name, nature-deficit disorder (Louv, 2005). Psychologists, physicians and other medical professionals are actively researching the benefits of plants to our well-being, including those in urban areas, as a result (see Shanahan et al., 2015, e.g., Tiffert et al., 2015).

### **Plant loss – current estimates, cause and regional challenges**

Despite the aforementioned value that plants bring to our lives, we are losing plant species at an alarming rate. According to the recently published report from Royal Botanic Gardens, Kew on the State of the World's Plants (2017), as many as one fifth of all plants on the planet, or an estimated 80,000 kinds of plants, will be extinct within the next century if current trends continue. Others estimate even higher rates, owing to under estimates of plant diversity in the tropics where narrow endemism is high and habitat destruction is perhaps most rampant (e.g., Pimm and Joppa, 2015, Pimm and Raven, 2017, Raven, this volume).

The causes of these dramatic declines in plants are multifaceted and include population and resource consumption, habitat loss and climate change. At current rates of consumption, the world's 7.5 billion people are consuming unsustainably, thus requiring increased land use and associated environmental degradation. Consumption is critical and mitigating these effects requires managing consumption rates and their effects on species loss (Chaudhary & Brooks, 2017). In developing regions, particularly the tropics, deforestation and overall habitat conversion continue to be a primary driver of species loss today (Watson, et al., 2016). Climate change, too, is substantially implicated in species extinctions and thought only to accelerate as trends continue (Raven, this volume).

Regionally, these collective challenges plants face are easily seen. Consumption, habitat conversion and climate change have been demonstrated

in numerous studies to threaten species globally, but particularly affecting vulnerable ecosystems such as islands, coastal environments, alpine regions and Mediterranean habitats. In the United States and Canada, here defined as North America north of Mexico and including the US outlying states and territories of Hawaii, Guam, American Samoa, Puerto Rico and the US Virgin Islands (the primary regions addressed in this paper), the loss is particularly pronounced.

Of the approximately 17,000 kinds of plants in the US and Canada, an estimated 4,400 kinds are ranked as critically endangered by NatureServe, the authority on species conservation assessment in this region (A. Francis, pers. comm.). Beyond these critically threatened species, more common species are also being threatened as land use and fragmentation continues, with new and emerging diseases, and with invasive plants and animals all threatening the overall plant diversity and ecological stability of this huge swath of planet Earth. It is clear that urgent and effective means to save these species are needed (see the Global Strategy for Plant Conservation for further justification in saving plant diversity around the world).

### **The Center for Plant Conservation – a model for collaboration**

To address the overwhelming need in the US and Canada to save plants from extinction, the Center for Plant Conservation was founded in 1984 with the guiding principal that plant conservation experts must come together to make a meaningful difference in preserving plant diversity for future generations (White, 2005). At the time it was recognized that considerable expertise was evolving among disparate organizations in the US and Canada and yet communication between these experts was limited. CPC was founded to bring these professionals together to share ideas and advance the science and practice of saving plants. This early CPC was comprised of ten institutions; today it has grown to over 60 organizations representing some of the world's best gardens, arboreta and conservation research organizations as well as environmentally committed, for-profit companies. Principally focused in the US, CPC Participating Institutions (PIs) and their conservation professionals are many of the world's experts in plant conservation. Using cutting-edge methods and the best science available, CPC Conservation Officers as they are known, do the hard work of saving plants for future generations.

CPC's mission is simple and proven: to ensure stewardship of imperiled native plants. CPC is a one-of-a-kind network that collaboratively works to save the imperiled plants of the US and Canada. CPC PIs maintain



the CPC National Collection of Endangered Plants, a living conservation collection of imperiled plants, by working to collect and manage living collections of seeds and plants for the long-term survival of these species and used to enhance and sustain wild populations as required. In particular, CPC PIs work to advancing our understanding of threats as well as means to save these species and, by communicating with partners within the CPC network, ensure that all are using the best and most up-to-date means possible to save imperiled plants (Center for Plant Conservation, 2019).

Greater than the sum of its parts, the CPC network saves more plant species together than would ever be possible alone. This is done through the timely sharing of information, data and expertise, and facilitated by the community of practice that is CPC where the world's experts regularly convene to discuss and apply methods that result in far greater numbers of plants saved from extinction.

CPC focuses efforts using the following tested and effective strategy:

- *Advance* science-based best practices in plant conservation through the CPC network of conservation partners known as Participating Institutions.
- *Apply* these practices to Save Plants from extinction in North America as part of the CPC National Collection of Endangered Plants.
- *Share* best practices with conservationists the world over and *advocate* for plants and their value to humankind.

## Results

To date, the Center for Plant Conservation and its network now have over one third of the US and Canada imperiled plants (~1,500 of 4,400 kinds) secured in the CPC National Collection. Active research programs in dozens of CPC organizations are all working to overcome conservation challenges for the remaining two thirds. Challenges such as seed storage, plant propagation and preservation/recovery of species in the wild, are all being addressed by these CPC partners (Center for Plant Conservation, 2019).

CPC's model of collaborative work with a shared responsibility to save plants has been used as the basis for other national and global efforts. The CPC guidelines (Center for Plant Conservation, and authors therein, 2019), developed over decades of intensive collaborative work, are currently used by these organizations and plant conservationists around the world to save plants.

CPC is now focused on creating better means to bridge the gap between scientific advancements and applied conservation outcomes. To this end, the CPC team is working on a new web-based data sharing and con-

ervation information platform known as Plant Nucleus. Plant Nucleus is the redevelopment of CPC's website into a go-to online resource community where CPC partners engage to save plants from extinction. This cloud-based community was born out of the need to better communicate and share best practices to address questions in ways that work for conservation professionals.

In looking at how CPC could serve the conservation community better, it was realized that the current conservation system was not set up to address conservation questions in ways that are both effective and efficient. It was also recognized that making data available in ways that increase knowledge and make conservationists better at saving plants was required. Plant Nucleus ideally will do all this by providing a one-stop resource where users are able to choose how to both use and share data. This freedom will ideally increase how fast knowledge is shared and will let conservationists focus on saving more plants. Time will tell if this approach will be successful.

## **Conclusions and future directions**

Plants provide tremendous benefit to humankind and the planet. Through regulating environmental cycles to providing essential resources for human health and happiness, plants are key to our very survival. However, global trends tell a story of under-appreciation and neglect for plants worldwide. Rates at which we are losing plant species are alarming; these trends affect every country on earth including the US and Canada where as many as one fourth of native plants of these two countries face extinction.

The Center for Plant Conservation has proven to be an effective model of collaboration, being a network of plant conservation professionals focused on saving the most imperiled species within a chosen region. With a core focus on advancing the science of saving plants, and through developing and implementing clear means to communicate these emerging best practices, CPC has managed to effectively conserve over one third of the imperiled plants in their target countries of the US and Canada.

To build on this success, more focus needs to be placed on bridging the gap between new discoveries and conservation outcomes. Too often we hear that new insights are not effectively shared or methods being used are outdated. Still other instances of duplicated work on the same species have occurred, resulting in wasted resources at best and with potentially negative outcomes for the species at worst. What is needed is a better means to share information, within a framework that works for those saving plants, and a system that inspires adoption and use.

## Bibliography

- Center for Plant Conservation. 2019. CPC Best Practices to Support Species Survival in the Wild. Center for Plant Conservation, Escondido, CA.
- Chaudhary, A. and T.M. Brooks. 2017. National consumption and global trade impacts on biodiversity. *World Development* 121: 178-187. <https://doi.org/10.1016/j.worlddev.2017.10.012>
- Ehrlich, P.R. and H.A. Mooney. 1983. Extinction, substitution, and ecosystem services. *BioScience* 33(4): 248-254. <https://doi.org/10.2307/1309037>
- Haines-Young, R. and M. Potschin. 2010. The links between biodiversity, ecosystem services and human well-being. In: Raffaelli, D. & C. Frid (eds.): *Ecosystem Ecology: a new synthesis*. BES Ecological Reviews Series, CUP, Cambridge.
- Hever, J. 2016. Plant-based diets: a physician's guide. *The Permanente Journal* 20(3): 93-101. <http://dx.doi.org/10.7812/TPP/15-082>
- Keniger, L.E., K.J. Gaston, K.N. Irvine and R.A. Fuller. 2013. What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health* 10(3): 913-935. <https://doi.org/10.3390/ijerph10030913>
- Khoury, C.K., S.L. Greene, S. Krishnan, A.J. Miller, and T. Moreau. 2019. A road map for conservation, use, and public engagement around North America's crop wild relatives and wild utilized plants. *Crop Science* 59: 1-6. <https://doi.org/10.2135/cropsci2019.05.0309>
- Louv, R. 2005. *Last Child in the Woods: Saving Our Children From Nature-deficit Disorder*. Chapel Hill, North Carolina.
- Petrovska, B.B. 2012. Historical review of medicinal plants' usage. *Pharmacognosy Review* 6(11): 1-5. <http://dx.doi.org/10.4103/0973-7847.95849>
- Pimm S.L. and L.N. Joppa. 2015. How Many Plant Species are There, Where are They, and at What Rate are They Going Extinct? *Annals of the Missouri Botanical Garden* 100(3): 170-176. <https://doi.org/10.3417/2012018>
- Pimm, S.L. and P.H. Raven. 2017. The fate of the world's plants. *Trends in Ecology and Evolution* 32: 317-320. <https://doi.org/10.1016/j.tree.2017.02.014>
- Quijas, S., B. Schmid, P. Balvanera. 2010. Plant diversity enhances provision of ecosystem services: A new synthesis. *Basic and Applied Ecology* 11(7): 582-593. <https://doi.org/10.1016/j.baae.2010.06.009>
- Shanahan, D.F., R.A. Fuller, R. Bush, B.B. Lin, and K.J. Gaston. 2015. The health benefits of urban nature: how much is enough? *BioScience* 65(5): 476-485. <https://doi.org/10.1093/biosci/biv032>
- Springmann, M., H.J. Godfray, M. Rayner, and P. Scarborough. 2016. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proceedings of the National Academy of Sciences* 113(15): 4146-4151. <https://doi.org/10.1073/pnas.1523119113>
- Veeresham, C. 2012. Natural products derived from plants as a source of drugs. *J Adv Pharm Technol Res.* 2012 Oct-Dec; 3(4): 200-201.
- Watson, J.E.M., K.R. Jones, R.A. Fuller, M. Di Marco, D.B. Segan, S.H.M. Butchart, J.R. Allan, E. McDonald-Madden, and O. Venter. 2016. Persistent disparities between recent rates of habitat conversion and protection and implications for future global conservation targets. *Conservation Letters* 9(6): 413-421. <https://doi.org/10.1111/conl.12295>
- White, P. Building a Noah's Ark for Plants (book review). 2005. *Bioscience* 55(6): 532-533.

## CAN BOTANIC GARDENS CONSERVE ALL OF THE WORLD'S RARE AND THREATENED PLANT SPECIES?\*

PAUL P. SMITH†

### Introduction

Plants are essential for human and other animal life on Earth in that they capture energy from the sun and convert it into food in the form of their seeds, leaves and roots. Human life is further sustained by the medicines, building materials and fuel that plants provide. Plants are central to many ecological processes such as climate regulation (including carbon dioxide absorption), soil fertility and the purification of both water and air. In spite of their importance, more than 80,000 seed-bearing plant species (20% of the total) are currently under threat (Brummitt *et al.*, 2015). This threat of extinction is largely due to habitat degradation, invasive alien species and over-exploitation, and is likely to be exacerbated by climate change. Furthermore, this threatened plant diversity will be essential to solving some of this century's major challenges in the areas of food security, energy availability, water scarcity, climate change and habitat degradation.

It is estimated that humans have modified more than 50% of the world's land surface (Hooke *et al.*, 2012), with approximately 40% given over to agriculture and livestock management. For plants with natural distributions that fall within these transformed areas, *ex situ* conservation or active human management may be the only way they can survive.

Even in national parks and wilderness areas not significantly altered or actively managed by people, plant populations may be vulnerable – particularly to invasive species, pests, diseases and a changing climate.

Botanic gardens offer the opportunity to conserve and manage a wide range of plant diversity *ex situ*, and *in situ* in the broader landscape. The rationale that botanic gardens have a major role to play in preventing plant

\* This paper is an updated version of Smith, P.P. (2016). Building a Global System for the Conservation of all Plant Diversity: a Vision for Botanic Gardens and for Botanic Gardens Conservation International. *Sibbaldia* 14, 5-13.

† Botanic Gardens Conservation International.

species extinctions through integrated plant conservation action is based on the following assumptions:

- There is no technical reason why any plant species should become extinct. Given the array of *ex situ* and *in situ* conservation techniques employed by the botanic garden community (seed banking, cultivation, tissue culture, assisted migration, species recovery, ecological restoration, etc.) we should be able to avoid species extinctions.
- As a professional community, botanic gardens possess a unique set of skills that encompass finding, identifying, collecting, conserving and growing plant diversity across the entire taxonomic spectrum.

Botanic gardens are a diverse community, fulfilling multiple objectives including attracting visitors, public education, scientific research, horticulture, and conservation. They have the potential to maximise their plant conservation impact by prioritising plant conservation action, becoming better organised as a professional community, and effectively communicating their role and objectives in plant conservation to policy makers, funders, and the general public.

Botanic Gardens Conservation International (BGCI) is a membership organisation, representing botanic gardens in more than 100 countries around the world. We aim to support and empower our members and the wider conservation community, including ordinary citizens, so that our knowledge and expertise can be applied to reversing the threat of extinction facing plants. Our vision is a world in which plant diversity is valued, secure, and supporting all life, and our mission is: “*To mobilise botanic gardens and engage partners in securing plant diversity for the well-being of people and the planet*” (Smith, 2018).

In this paper I will set out how we will achieve this mission through the establishment and promotion of a botanic garden-centred Global System for the conservation and management of plant diversity that aims to collect, conserve, characterise and cultivate samples from all of the world’s rare and threatened plants as an insurance policy against their extinction in the wild and as a source of plant material for human innovation, adaptation and resilience.

### **The concept of a rational, cost-effective Global System**

The Global System approach is exemplified by the endeavours of the global crop research community. Despite its importance to food security, much of the world’s crop diversity is neither safely conserved, nor readily available to scientists and farmers who rely on it to safeguard agricultural

productivity. Crop diversity is being lost, and with it the biological basis of our food supply. Given the urgent need to achieve food security in the face of a changing climate and burgeoning human population, the crop research community has developed the concept of a cost-effective, rational Global System for the conservation and sustainable use of plant genetic resources in food and agriculture. This Global System, established by the Food and Agriculture Organisation of the United Nations (FAO, 2011), comprises elements of policy, planning, a review process, physical infrastructures, human resources, germplasm collections and data. It consists of:

- The International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA),
- The Global Plan of Action for PGRFA,
- A review process (State of the World's PGRFA),
- A network of international institutions and crop collections,
- A global portal of accession-level data (Genesys),
- A universal gene bank information management system (GRIN Global),
- Advanced bioinformatics tools that allow users to mine crop characterisation data (DIVSEEK).

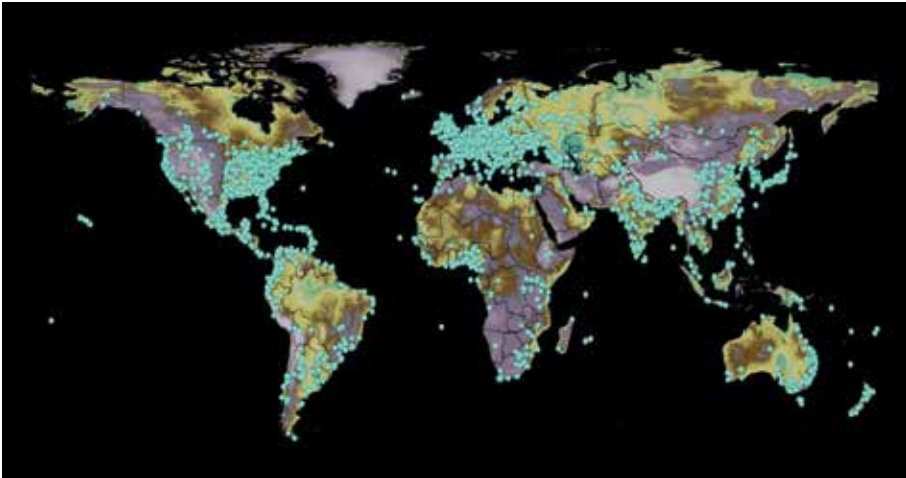
Compared to the botanic garden community, the crop community is highly centralised around the FAO and the 11 multilateral germplasm collections in the gene banks of the Consultative Group on International Agricultural Research (CGIAR). Likewise, the International Treaty – in theory at least – facilitates access to material and data between national gene banks, multilateral gene banks and users. No such centralised, multilateral infrastructure exists for botanic gardens. Nevertheless, there are strong parallels with the policy, infrastructural and collections frameworks that exist in the botanic gardens community.

### **A Global System for botanic gardens**

Following the example of the crop conservation community, a botanic garden-centred Global System for the conservation and management of plant diversity aims to collect, conserve, characterise and cultivate samples from all of the world's rare and threatened plants as an insurance policy against their extinction in the wild and as a source of plant material for human innovation, adaptation, and resilience. This Global System comprises the following components:

- A global policy framework: the Convention on Biological Diversity,
- A global action plan: the Global Strategy for Plant Conservation,

- A review process: the Global Partnership for Plant Conservation,
- A collections infrastructure comprising an international network of botanic gardens and their living collections,
- A global portal of plant collection data,
- An array of data sources providing access to phenotypic and genotypic data enabling conservation and use of the collections for human development and well-being,
- A range of tools, resources and activities that aims to increase awareness and participation in plant conservation resulting in wide reaching benefits for society.



**Figure 12.1** There are over 3000 botanic gardens in the world. Source: GardenSearch [http://www.bgci.org/garden\\_search.php](http://www.bgci.org/garden_search.php)

Most of the policy, planning and review architecture already exists, as indicated above. In addition, BGCi itself sits at the centre of a network of more than 3,000 botanic gardens in over 100 countries around the world (Figure 12.1), which includes the following:

### **World-leading infrastructures**

Kew's Millennium Seed Bank, the Royal Botanic Garden, Sydney's Plant Bank, and Kunming Institute of Botany's Gene Bank of Wild Species are the largest, most sophisticated seed banks in the world. The sector is equally strong in glasshouse and horticulture infrastructures and is more

than adequately served with micro-propagation facilities and molecular laboratories. The botanic garden community's most comprehensive data source on garden facilities and foci is BGCI's GardenSearch,<sup>1</sup> a web-based directory of the world's botanic gardens comprising information on 3,571 botanic gardens and arboreta worldwide.

### **Comprehensive living plant collections**

These cover at least a third of total known plant diversity. BGCI's PlantSearch database (BGCI, 2019) includes 1,398,542 collection records, representing 556,338 taxa, at 1,119 contributing institutions around the world. A recent study (Mounce *et al.*, 2017) found that the botanic gardens included in PlantSearch manage at least 105,634 species, equating to 30% of all vascular plant species, 57% of vascular plant genera and an astonishing 93% of all vascular plant families. These collections include over 41% of known threatened species. There are, of course, caveats such as the fact that accession records are not always up to date or accurately named. However, this can be balanced against the fact that PlantSearch itself is not comprehensive, covering only about 40% of all botanic gardens.

### **Well-curated data sources**

BGCI's PlantSearch database<sup>2</sup> is the most comprehensive register of the names of plants grown in botanic gardens. However, although it indicates which species are grown where, it does not enable the user to identify a specific collection that might be useful in plant conservation or for research. Therefore, the most pressing need is that PlantSearch becomes a portal to individual accessions and their data held in specific botanic gardens and ultimately becomes a means by which gardens can exchange material for conservation purposes in much the same way that the zoo community uses its International Species Information System (now called Species360) as a stud book for captive breeding (Conde *et al.*, 2011). PlantSearch 2.0, which will trial this approach, will be launched in 2020. BGCI also manages 'ThreatSearch', the most comprehensive consolidated list of plant threat assessments in the world. This database comprises, global, regional and national assessments, and currently includes over 300,000 assessments covering >180,000 taxa,<sup>3</sup> and enables botanic gardens to identify

<sup>1</sup> [http://www.bgci.org/garden\\_search.php](http://www.bgci.org/garden_search.php)

<sup>2</sup> [http://www.bgci.org/plant\\_search.php](http://www.bgci.org/plant_search.php)

<sup>3</sup> see [http://www.bgci.org/threat\\_search.php](http://www.bgci.org/threat_search.php)



the world's rarest and most threatened plant species so that they can give these species top priority.

### **BGCI's role in building and co-ordinating the Global System**

Sitting at the centre of a network of botanic gardens in 100 countries, including the largest and most influential gardens in our sector, BGCI and its regional and national partners are in a prime position to promote a more efficient, cost-effective and rational approach to plant conservation in botanic gardens. BGCI has strategic partnerships with national associations of botanic gardens, such as the Center for Plant Conservation in the USA and the Chinese Union of Botanical Gardens in China. We have similar partnerships with regional associations such as the European Consortium of Botanic Gardens, the South East Asian Botanic Garden Network and the African Botanic Garden Network. Building on the objectives outlined in BGCI's Strategic Plan (BGCI, 2015), we can mobilise botanic gardens in four ways, by:

1. *Leading and advocacy:* We will provide leadership to the botanic gardens sector, and promote the role of botanic gardens to policymakers and funders in delivering the Global Strategy for Plant Conservation (2010). This is already happening as an increasing number of countries incorporate the Global Strategy into their National Biodiversity Strategies and Action Plans (Sharrock *et al.*, 2014). In addition, through our strong links with the UN, botanic gardens are already recognised as playing an important role in the conservation and use of plant genetic resources in agriculture (FAO, 2011) and forestry (FAO, 2014). BGCI's International Advisory Council, which currently comprises directors from 30 botanic gardens on six continents, is the closest approximation to a global leadership forum that the botanic gardens sector has. This body speaks with one voice on the primary importance of plant conservation in our sector.
2. *Leading and co-ordinating innovative and strategic projects achieving outcomes in plant conservation policy, practice and education:* At the global level, BGCI leads and co-ordinates consortia of botanic gardens with specific expertise within the broader network. These include:
  - a. providing the secretariat for the Global Partnership for Plant Conservation which measures progress towards the GSPC targets (Plants 2020, 2010);

- b. providing the secretariat to IUCN's Global Tree Specialist Group and co-ordinating the Global Tree Assessment<sup>4</sup> which aims to have assessed the threat status of all known trees by 2020 (Newton *et al.*, 2015);
  - c. co-ordinating the Global Seed Conservation Challenge <https://www.bgci.org/plant-conservation/seedconservation/>,<sup>5</sup> a consortium of 200 botanic gardens with seed banks;
  - d. co-ordinating Global Conservation Consortia for exceptional taxa such as *Magnolia*, *Acer*, *Rhododendron* and *Quercus*;
  - e. co-managing the Global Trees Campaign with Fauna & Flora International, which aims to avoid all tree species extinctions through integrated tree conservation action;<sup>6</sup>
  - f. co-ordinating and providing the secretariat for the Ecological Restoration Alliance of Botanic Gardens (ERA), a consortium that currently includes 40 botanic gardens carrying out more than 200 restoration projects across the globe<sup>7</sup> (Shaw *et al.*, 2015);
  - g. co-ordinating the International Plant Sentinel Network, a consortium of 26 botanic gardens that comprise an early warning system for new plant pests and diseases<sup>8</sup> (Barham *et al.*, 2015) and;
3. *Building plant conservation capacity in botanic gardens and other sectors:* BGCI's website is already widely used by the botanic garden community as a source of information on running a modern botanic garden, particularly through the latest iteration of BGCI's botanic garden manual (BGCI, 2016). However, we are working hard to augment this information with resources and tools covering specific disciplines, including red listing, seed conservation, tree conservation, ecological restoration, plant health and public engagement. In addition, BGCI currently provides training courses on plant conservation policy, red-listing, seed conservation, ecological restoration, nursery techniques and public engagement. These courses are aimed at supporting smaller botanic gardens but also professionals in other sectors such as foresters and national park managers.
  4. *Providing funding:* BGCI is committed to accelerating our fundraising efforts in order to mobilise funding to deliver plant conservation projects and outcomes, prioritising smaller, resource-poor botanic gardens in bi-

<sup>4</sup> <http://globaltreeassessment.org/>

<sup>5</sup> <https://www.bgci.org/plant-conservation/seedconservation>

<sup>6</sup> <http://globaltrees.org/>

<sup>7</sup> <http://www.erabg.org/>

<sup>8</sup> <http://www.plantsentinel.org/>

odiversity hotspots. Currently, BGCI disburses around ten times what it receives in subscriptions back into the botanic garden sector – primarily for plant conservation and education activities. Traditionally, this funding comes mainly from trusts and foundations. Over the next five years our aim is to double that funding by building a global botanic garden endowment fund that will be used to generate regular income to support botanic garden-centred plant conservation activities on the ground.

### **Accepting the challenge: the role of the botanic garden community**

Notwithstanding our impressive array of resources as a global community, substantial investment will be required to build a fully functioning Global System that can prevent species extinctions in perpetuity. Perhaps the most important thing we need to do is to agree, as a professional community, that we are going to take on the challenge of plant species extinctions. Only by presenting a united front, and showing that commitment, are we going to convince policymakers and funders that we have a substantial role to play.

Secondly, we need to promote plant conservation action in botanic gardens. This activity is currently competing with the other functions of botanic gardens, particularly the need to increase visitor numbers and generate income. Plant conservation activities in botanic gardens can be substantial or limited and may include plant conservation policy, practice or education. What is important is that all botanic gardens do *something* – preferably plant conservation action, and with local relevance. Although botanic gardens currently grow or conserve 42% of threatened plant species, only about 10% of their collections effort is directed at rare and threatened species (Mounce et al., 2017).

Thirdly, we need to better co-ordinate our work, and focus botanic garden efforts on the gaps, i.e. making sure that we tackle the rarest, most threatened and most challenging species. Although we maintain a third of known plant diversity in our living collections and seed banks, there are major gaps in our collections, infrastructures, knowledge and expertise. Mounce et al. (2017) point out that, although 60% of temperate vascular plants are grown in botanic gardens, only 25% of tropical species are represented. This is largely due to the fact that 82% of botanic gardens are located in the Northern Hemisphere (Figure 12.1) and there is insufficient expertise and resources in the tropics. In addition, botanic gardens grow or conserve less than 5% of non-vascular plants (mosses, liverworts etc.) despite the fact that they are ecologically important and many of them are threatened.

Fourthly, we need to acknowledge that we cannot work in isolation. An *ex situ* seed or living collection is the means to an end, not the end in itself. The aim is to achieve self-perpetuating populations of plants out in the broader landscape. This means working in an integrated way with *in situ* conservationists (e.g. park managers, NGOs etc.), foresters, farmers and other sectors that manage transformed landscapes. Explicitly, this also means that botanic gardens need to go out beyond their garden walls, and learn new disciplines. A large number of botanic gardens already manage wild areas and native species assemblages so this is not a huge ideological leap. However, we haven't always been good at working in partnership with other professional sectors.

Finally, we need to facilitate plant conservation action in broader society through stimulating public dialogue, creating opportunities for participation in local and global conservation efforts and through provision of education, tools and information. At the same time, we need to be careful that our plant conservation effort does not begin and end here. Currently, too many gardens argue that they are fulfilling their role by simply informing the public about the need for plant conservation. This approach conveniently ignores the fact that our sector has the technical skills that broader society does not have, and that with those skills comes responsibility.

## Conclusions

The loss of plant diversity is the most urgent and important issue that botanic gardens need to address but it is not always seen as a priority given the multiple roles that botanic gardens are expected to fulfil. Botanic gardens, as a professional community, possess unique knowledge and skills to find, identify, conserve and manage plant diversity in the landscape and, for this reason, they need to show greater leadership in plant conservation. To be most effective the sector needs to organise itself in a rational and cost-effective way by sharing knowledge and enabling all botanic gardens to carry out effective plant conservation in their own geographic or taxonomic spheres. Botanic Gardens Conservation International and its national and regional partners are ideally placed to facilitate this approach.

## Bibliography

- Barham, E., Sharrock, S. & Baker, R. (2015). An International Plant Sentinel Network. *Sibbaldia*, 13: 83–98. Royal Botanic Garden Edinburgh.
- Brummitt, N.A. et al. (2015) Green plants in the red: a baseline global assessment for the IUCN Sampled Red List Index for Plants. *PLoS ONE* 10, e0135152. <https://doi.org/10.1371/journal.pone.0135152>
- Conde, D.A., Flesness, N., Colchero, F., Jones,

- O.R., Scheuerlein, A. (2011). An emerging role of zoos to conserve biodiversity. *Science* 331(6023): 1390-1391. <https://doi.org/10.1126/science.1200674>
- FAO (2011). The Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture. Commission for Genetic Resources for Food and Agriculture, FAO.
- FAO (2014). The State of the World's Forest Genetic Resources. Commission for Genetic Resources for Food and Agriculture, FAO.
- Global Strategy for Plant Conservation (2010). Last accessed on October 23, 2019, at <https://www.cbd.int/gspc/strategy.shtml>
- Hooke, R.L., Martin-Duque, J.F. & Pedraza, J. (2012) Land transformation by humans: a review. *GSA Today* 22(12): 4-10. <https://doi.org/10.1130/GSAT151A.1>
- Mounce, R., Smith, P. & Brockington, S. (2017). Ex situ conservation of plant diversity in the world's botanic gardens. *Nature Plants* 3: 795-802. <https://doi.org/10.1038/s41477-017-0019-3>
- Newton, A., Oldfield, S., Rivers, M., Mark, J., Schatz, G., Tejedor Garavito, N., Cantarello, E., Golicher, D., Cayuela, L. & Miles, L. (2015). Towards a Global Tree Assessment. *Oryx* 49: 410-415. <http://dx-doi.org/10.1017/S0030605315000137>
- Plants 2020 (2010). Last accessed on May 1, 2019, at <http://www.plants2020.net/gppc>
- Sharrock, S., Oldfield, S. & Wilson, O. (2014). *A review of progress in implementation of the Global Strategy for Plant Conservation 2011-2020*. Plant Conservation Report 2014: Secretariat of the Convention on Biological Diversity, Montréal, Canada and Botanic Gardens Conservation International, Richmond, UK. Technical Series No. 81, 56 pages.
- Shaw, K., Nicholson, M. & Hardwick, K. (2015). Encouraging and enabling a science-based approach to ecological restoration: an introduction to the work of the Ecological Restoration Alliance of botanic gardens (ERA). *Sibbaldia*, 13: 145-152. Royal Botanic Garden Edinburgh. <https://doi.org/10.23823/Sibbaldia/2015.80>
- Smith, P. 2018. Growing public engagement impact: Opportunities and challenges for botanic gardens. Last accessed on November 18, 2019, from *Botanic Gardens Conservation International* at <https://www.bgci.org/wp/wp-content/uploads/2019/07/Smith-Paul-Growing-public-engagement-impact.pdf>

## CONSERVATION-ORIENTED RESTORATION AS A PRIMARY SOLUTION

SERGEI VOLIS\*

### Introduction

It was recognized as early as the 1990s that land protection is by no means a guarantee of the long-term species survival (Possiel et al. 1995; Maxted et al. 1997; Dopson et al. 1999). There is no doubt that legal protection is important in securing threatened species by protecting them from the immediate and most detrimental threats (e.g. logging, grazing, and poaching), but mere designation of protected areas, which has been and continues to be the primary approach to conserving biodiversity, is not enough (e.g. Brashares, 2001; Clark, 2013; Havens et al. 2014; Bridgewater 2016; Heywood 2016, 2017, 2018). There are several reasons why reliance on passive conservation through strict area protection that prohibits any modifications of the protected habitat to address threats to inhabiting its species is rather a dead end than the working strategy.

One reason why protection alone is the flawed strategy is the ongoing climate change. For many species with limited dispersal abilities, narrow environmental niches and populations scattered in the fragmented landscapes, even if all their populations are protected, the anticipated climate changes can drive them to extinction, unless some additional measures to adjust their ranges are taken. Another, even more important reason is the anthropogenic disturbance that left virtually no scrap of land (including those in protected areas) untouched, and disrupted previously existing species interactions and ecological processes (e.g., Chapman, 2010). Habitat fragmentation and deterioration that resulted from this disturbance reduced population sizes of many species below the viability threshold or made regeneration impossible. Last remaining individuals indicate that population recovery at that location is possible in principle, but only if the factors contributing to the population's decline or failure to regenerate are identified and addressed. Elimination of these factors in the majority of situations requires interventions that will either maintain crucial eco-

\* Katif Center for Research and Development of Coastal Deserts, Israel.

systems' dynamic processes such as succession, or remove the dispersal and establishment limitations responsible for the reduced or absent recruitment.

Protection (i.e. legislating an area as protected by law) by definition does not assume a need in any modifications/alterations of the protected habitat. Therefore, passive protection alone cannot solve the problems outlined above. Unfortunately, the other conservation practices available, applied alone or together with protection, are equally unable to tackle this issue. A brief list of conservation practices available today includes:

- assessments of biodiversity summarized in IUCN species categorization and creating global, national and regional lists of threatened species;
- global and regional prioritization of species, habitats and areas for conservation;
- preservation of threatened species in *ex situ* seed banks and botanic garden living collections with minimal coordination between *ex situ* and *in situ* actions;
- reinforcement or reintroduction of endangered species usually conducted at single or very few locations;
- minor interventions in protected areas usually limited to control of invasive species and prescribed burning.

All these practices implicitly assume that the target habitat is intact or almost intact. If this was the case, protection with minor habitat interventions would do the job. Unfortunately, historically authentic, co-evolved biotic assemblages have largely disappeared being replaced by new combinations of species living under environmental conditions that have no historical analogs (Hobbs et al. 2006, Hobbs, 2013). In these new world realities, when virtually no habitat is intact, the listed above practices are of little use. They can become useful only if integrated into a new, creative and flexible approach able to deal with the altered habitats, and guarantee long-term species survival via restoring recruitment in existing populations and creating new viable populations. Given the lack of regeneration in many populations of threatened species, even in strictly protected areas, land protection must foster instead of forbidding the interventions that help restore species recruitment. This means that the new approach should be based on integration of conservation biology and restoration ecology.

A need for such integration has been recognized (Dobson et al. 1997; Young 2000; Burney and Burney 2007) but no attempt has been made to develop this general idea into a coherent concept.

Conservation biology focuses on processes that occur in populations of threatened species, while ecological restoration concentrates on community and ecosystem processes. The goal of the former is to ensure species persistence in their natural habitats, while the latter seeks to revitalize degraded ecosystems. However, to divert a threatened species from a path to extinction we need to identify and remove its threat, which almost certainly in any particular case is anthropogenic disturbance, be it logging, cash crop planting, invasion by alien species, changed hydrological regime, etc. Removal of these threats requires restoration of once existing conditions, and this is the field of ecological restoration. Thus, conservation biology and ecological restoration are inherently linked. Moreover, restoration of once existing conditions can be done not only FOR threatened species, but also USING threatened species when the latter satisfy certain requirements, as will be shown below.

### **Conservation-oriented restoration**

I propose that efficient conservation of biodiversity can be achieved only by applying interventions to partly degraded habitats and that habitat restoration (instead of focal species and their populations) must become a focus of plant conservation. The concept based on these premises called conservation-oriented restoration adopts the idea of creating partly novel (i.e. having species compositions that differ from historical analogs) ecosystems, but with the goal of conservation of threatened species and their habitats, regardless of whether this will improve the ecological services for local human population or not. The concept is described in detail in (Volis, 2016, 2016a; 2018, 2019) and below I provide a summary of the distinct features of the proposed concept.

### **Threatened species can be used in restoration**

An idea of usage of threatened species in restoration has the following logic. On one hand, the majority of the threatened species will have a future only in restored habitats. On the other hand, nowadays so many species are imperiled that it should be possible to choose species to be used in restoration plantings, which not only belong to the functionally important plant category, a category needed to restore the ecosystem integrity, but which are threatened themselves. The opponents of this idea may say that most of the threatened species have narrow ecological niche, poorly known biology and other features making them a problematic material for large-scale planting. This is (at least partly) true. However, many of the



currently rare species are likely to be “anthropogenic rarities” (Fiedler and Laven 1996), i.e. species whose dramatic reduction in range and abundance, in comparison with other species, is due to higher vulnerability to alteration of once existing habitats and biotic interactions. Such species whose decline and range contraction are due to extrinsic factors (e.g. invasion of non-native species, livestock grazing, fire suppression or land conversion), may turn out to be useful for restoration of altered or partly degraded habitats both inside and outside their current range. Moreover, uncertainty about a cause of rareness regarding many threatened species paired with a high probability that they are anthropogenic rarities, should stimulate substantial broadening of lists of candidate species for habitat restoration with threatened species. If introduced into a variety of locations within their potential distribution range, they can become common or even dominant species in some of the restored ecosystems.

Comparisons of rare species with congeneric common species show similar fecundity and germination rates (Carlsen et al. 2002; Fu et al. 2009) as well as size classes distributions (Byers and Meagher 1997; Kelly et al. 2001). Establishment of introduced threatened plant species in restoration projects is similar to the establishment of non-threatened species (Morgan 1999; Shono et al. 2007; Cordell et al. 2008; Millet et al. 2013; Schneider et al. 2014; Subiakto et al. 2016). Potential limits to the utilization of threatened species in restoration projects are the requirement of large seed quantities as well as a lack of knowledge of the species’ reproductive biology and efficient methods of propagation and planting. However, the former problem of propagule supply can be efficiently solved by the *quasi in situ* living collections as explained below, and the crucial knowledge about threatened species propagation, although still very limited, is steadily accumulating (e.g. Iturriaga et al. 1994; Sakai et al. 2002; Danthu et al. 2008; De Motta 2010; Herranz et al. 2010; Kay et al. 2011; Ratnamhin et al. 2011; Koch and Kollmann 2012; Castellanos-Castro and Bonfil 2013; Gratzfeld et al. 2015; Lu et al. 2016). Once the necessary knowledge comparable to those for common species is acquired and protocols are available, the cost per seedling will make restoration practitioners more likely to incorporate rare and threatened species into their plans (Rodrigues et al. 2011).

### **Area prioritization should be based on presence of threatened species and degree of degradation**

Hobbs et al. (2013) recognized three types of ecosystems: those remaining within their natural range of variability, those where anthropogenically

caused changes are reversible, and those where such changes are irreversible (historical, hybrid, and novel ecosystems, respectively). Among these three ecosystem types, only hybrid ecosystems (beside historical ones) can be a home for threatened species, but not all hybrid ecosystems will have the same conservation value. The priority should be given to the least altered habitats, which still need interventions to restore altered structure and some missing ecological functions but which have a reasonable chance of approaching a once-existing habitat, and to those habitats in which threatened species still grow. I propose the following rankings of the areas targeted for conservation-oriented restoration by their conservation value:

- habitats in which highly endangered plant species still have populations and these populations exhibit natural regeneration;
- habitats in which highly endangered plant species still have populations but natural regeneration in these populations has not been observed or is depressed;
- habitats which are least degraded among other similar systems and which can potentially support establishment of endangered species currently not growing there;
- habitats of varying degree of disturbance that are located within protected areas or are important for their connectivity; and
- habitats of varying degree of disturbance that have a low probability of supporting establishment of endangered species but have a good chance of approaching (after restoration) historical habitats regarding species structure and composition.

### **Multiple stable states for an ecosystem can be targeted as reference conditions**

Any restoration project requires reference conditions, which are used for the comparison with a contemporary ecosystem to evaluate the changes, design of the management actions, and measuring success of ecological restoration. A reference in a conservation-oriented project should not be a single ecosystem state but the historical range of variability in ecosystem composition, structure, and function. Such view is based on the assembly rules theory of theoretical community ecology according to which community assembly is deterministic in the composition of trait-based functional groups, but stochastic in terms of species composition. Besides, extant populations of threatened species usually are located in small size remnants of a natural habitat representing only a subset of the habitat's original abiotic and biotic variation.

In working out a reference, it is important to take into account climatic fluctuations that occurred in the past, and especially important to consider climate changes that happen nowadays. This means that the restored ecosystems should be re-aligned with current and expected future conditions rather than with a single pre-disturbance state.

### **Choice of species should be based on “dark diversity” concept**

According to Helm et al. (2015), the observed community diversity represents two species pools of different historical backgrounds. The first one, called characteristic diversity, consists of species that historically evolved in a region and represent a habitat-specific regional species pool, and the second one, called derived diversity, represents aliens whose presence is due to intended or unintended human impact. The regional species pool should be the major, and in many cases the only source of species to be introduced. However, in some cases, species from the second group can be selected, for example, if a functionally important species went extinct and needs a replacement by a functional analog not presented in the regional species pool; or when an endangered species has no suitable habitat in the whole region to which it belongs.

Compiling species lists for conservation-oriented restoration should adopt an idea of “dark diversity” (Partel et al. 2011). The species from the regional species pool absent in the characteristic diversity pool can be considered representatives of the “dark diversity” group, that is, the set of species in a region that currently do not inhabit a site due to dispersal or establishment limitations. Many of these species could have disappeared from a site due to human-caused alteration of abiotic and biotic conditions, or direct exploitation. Introduction of the species from the regional species pool can convert dark diversity into characteristic diversity.

### **Conservation interventions should be done in an experimental manner**

To succeed, active interventions should be applied in an experimental manner rather than as a single “optimal” treatment for a number of reasons. For protected areas, to enable working out the efficient management scheme it would be desirable to apply a variety of experimental treatments among and within protected areas, so that some areas remain untouched while others are managed, and managed differently. A comparison of the outcomes will make it possible to identify the best treatment(s) to facilitate the transition of ecosystems along desired trajectories (Radeloff et al. 2015). For example, a site may include the creation of favorable mi-

cro-sites for the target species such as canopy gaps, deadwood, mounds or pits. Artificial creation of such micro-sites has a lot of uncertainty because the optimal levels of required intervention differ among species. Thus, the variety of disturbance types and their levels need to be tested for working out the optimal intervention required to create suitable conditions for the target species.

Experimentation is also needed for mitigating climate change effects. Potential species niche can be determined through species distribution modeling and used to predict the anticipated range shifts, but no modeling can predict the presence of suitable microsites, mutualistic biota or detrimental herbivores. Because responses to climate are usually species-specific, climatic changes will result in complex and difficult-to-predict novel species combinations. As a result of range shifts and competition, species with previously non-overlapping ranges will under new conditions reassemble into presently not existing communities and ecosystems (Williams and Jackson 2007; Hobbs et al. 2009; Gilman et al. 2010). While many of these new ecosystems will be unsuitable for imperiled species, limited scale translocation trials will help to identify those in which they may find a new home.

Conservation-oriented restoration projects should always be preceded by experiments investigating species- and treatment-specific responses. This can be done by applying mosaics of replicated treatments within mosaics of habitats (Howe and Martinez-Garza 2014). Modified in this way, the introduced micro-sites will differ in species composition, mostly in presence and abundance of rare species, and will serve as sources of colonization for each other. Thus, broadening the list of species introduced in different combinations and treatments (Howe and Martinez-Garza 2014) and replicating introduced populations over time and space (Guerrant 1996; Dani Sanchez et al. 2018) is a way to maximize the likelihood of reintroduction success in projects using threatened species because introductions of such species are often unsuccessful (Maunder 1992; Seddon et al. 2007; Godefroid et al. 2011; Dalrymple et al. 2012; Drayton and Primack 2012).

### **Ex situ and in situ approaches must be integrated**

Restoration of a habitat may not be limited to, but as a rule includes introducing plant material, predominantly in a form of seedlings or saplings. Plant germplasm maintained and propagated *ex situ* can be used for this purpose but limitations of *ex situ* collections in botanical gardens and arboreta for producing outplants are well known (Simmons, 1976; Hamilton 1994; Schoen and Brown 2001; Maunder et al. 2004; Volis and Blecher

2010). A way to bridge *ex situ* and *in situ* to make the former a source of material for the latter is to create living collections of needed capacity outside botanic gardens and arboreta in natural or seminatural settings. Such *quasi in situ* collections (Volis and Blecher 2010; Volis 2016d), besides preserving species genetic variation, can be a reliable source of seeds for *in situ* conservation and restoration projects. Seed banks cannot fulfill this task due to space limitations and problems with storing non-orthodox seeds, while collecting large quantities of seeds in natural populations is either impossible or undesirable due to the negative impacts of seed harvesting on local population dynamics. For species whose seed output is low or varies greatly from year to year, or for species represented by small populations suffering from inbreeding depression, *quasi in situ* collections can be a solution because in these collections cross-pollination of plants originated from several populations will result in the production of healthy, well-performing offspring (Volis 2016c). These offspring can be produced with certainty, at no or very low cost, and collected in the large quantities required by nurseries producing seedlings of rare and threatened species.

### **Legislation must allow active interventions**

Habitat protection is a vital component of the proposed strategy because it prohibits activities that can damage, destroy or modify the target habitats. However, the strictest protection does not guarantee a halt to further degradation of the habitat and species loss. This halt often is impossible to achieve without well-organized interventions and clear recovery criteria to follow. However, the interventions must be allowed by the protection status of the target site. Unfortunately, virtually all interventions which may require restoration of a habitat (e.g. introduction of a suite of functionally important for the ecosystem species, creation of deadwood, thinning of pioneer in favor of late-successional tree species, liberation of juveniles of threatened species from competing vegetation, and various forms of translocation) are not allowed in strictly protected areas (Categories I-II) (Dudley 2008).

To make implementation of conservation-oriented restoration possible, the current categories must be re-defined to permit i) management through active interventions while forbidding any unauthorized activities, and ii) introduction of critically endangered species based on predictions of species distribution modeling even if there are no records of their past occurrence.

## Bibliography

- Brashares, J.S., Arcese, P., Sam, M.K., 2001. Human demography and reserve size predict wildlife extinction in West Africa. *Proceedings of the Royal Society of London, Series B* 268, 1–6.
- Bridgewater, P., 2016. The Anthropocene biosphere: do threatened species, Red Lists, and protected areas have a future role in nature conservation? *Biodiversity and Conservation* 25, 603–607.
- Burney, D.A., Burney, L.P., 2007. Paleoecology and “inter-situ” restoration on Kauai, Hawaii. *Frontiers in Ecology and Environment* 5, 483–490.
- Byers, D.L., Meagher, T.R., 1997. A comparison of demographic characteristics in a rare and a common species of *Eupatorium*. *Ecological Applications* 7, 519–530.
- Carlsen, T.M., Espeland, E.K., Pavlik, B.M., 2002. Reproductive ecology and the persistence of an endangered plant. *Biodiversity and Conservation* 11, 1247–1268.
- Castellanos-Castro, C., Bonfil, C., 2013. Propagation of three *Bursera* species from cuttings. *Botanical Sciences* 91, 217–224.
- Chapman, C.A., Chapman, L.J., Jacob, A.L., Rothman, J.M., Omeja, P., Reyna-Hurtado, R., Hartter, J., Lawes, M.J., 2010. Tropical tree community shifts: Implications for wildlife conservation. *Biological Conservation* 143, 366–374.
- Clark, N.E., Boakes, E.H., McGowan, P.J., Mace, G.M., Fuller, R.A., 2013. Protected areas in South Asia have not prevented habitat loss: a study using historical models of land-use change. *PLoS ONE* 8, e65298.
- Cordell, S., McClellan, M., Yarber Carter, Y., Hadway, L.J., 2008. Towards restoration of Hawaiian tropical dry forests: the Kaulapulehu outplanting programme. *Pacific Conservation Biology* 14, 279–284.
- Dalrymple, S.E., Banks, E., Stewart, G.B., Pullin, A.S., 2012. A meta-analysis of threatened plant reintroductions from across the globe, In *Plant reintroduction in a changing climate: promises and perils*. eds J. Maschinski, E.H. Haskins, pp. 31–50. Island Press, Washington, DC.
- Dani Sanchez, M., Manco, B.N., Blaise, J., Corcoran, M., Hamilton, M.A., 2019. Conserving and restoring the Caicos pine forests – the first decade. *Plant Diversity* 41, 75–83.
- Danthu, P., Ramarosan, N., Rambeloarisoa, G., 2008. Seasonal dependence of rooting success in cuttings from natural forest trees in Madagascar. *Agroforestry Systems* 73, 47–53.
- De Motta, M.J., 2010. A history of Hawaiian plant propagation. *Sibbaldia* 8, 31–43.
- Dobson, A.P., Bradshaw, A.D., Baker, A.J.M., 1997. Hopes for the future: Restoration ecology and conservation biology. *Science* 277, 515–522.
- Dopson, S.R., de Lange, P.J., Ogle, C.C., Rance, B.D., Courtney, S.P., Molloy, J., 1999. The conservation requirements of New Zealand’s nationally threatened vascular plants. *Threatened Species Occasional Publication No. 13*. New Zealand Biodiversity Recovery Unit Department of Conservation, Wellington.
- Drayton, B., Primack, R.B., 2012. Success rates for reintroductions of eight perennial plant species after 15 years. *Restoration Ecology* 20, 299–303.
- Dudley, N. ed., 2008. *Guidelines for applying protected area management categories*. IUCN, Gland, Switzerland.
- Fiedler, P.L., Laven, R.D., 1996. Selecting reintroduction sites, In *Restoring Diversity: strategies for reintroduction of endangered plants*. eds D.A. Falk, C.I. Millar, M. Olwell, pp. 157–170. Island Press, Washington, DC.
- Fu, Y., Chen, S., Wu, T., Hao, J., Sima, Y., 2009. Comparison of seed modality and germination characteristics of compare of *Manglietia hookeri* and endangered *M. grandis*. *Journal of Northwest Forestry College* 24, 33–37.

- Gilman, S.E., Urban, M.C., Tewksbury, J., Gilchrist, G.W., Holt, R.D., 2010. A framework for community interactions under climate change. *Trends in Ecology & Evolution* 25, 325–331.
- Godefroid, S., Piazza, C., Rossi, G., Buord, S., Stevens, A.D., Aguraitua, R., Cowell, C., Weekley, C.W., Vogg, G., Iriondo, J.M., Johnson, I., Dixon, B., Gordon, D.R., Magnanon, S., Valentin, B., Bjureke, K., Koopman, R., Vicens, M., Virevaire, M., Vanderborcht, T., 2011. How successful are plant species reintroductions? *Biological Conservation* 144, 672–682.
- Gratzfeld, J., Kozłowski, G., Fazan, L., Buord, S., Garfi, G., Pasta, S., Gotsiou, P., Fournaraki, C., Dimitriou, D., 2015. Whither rare relict trees in climate of rapid change? *BGjournal* 12, 21–25.
- Guerrant, E.O.J., 1996. Designing populations: demographic, genetic and horticultural dimensions. In *Restoring diversity. Strategies for reintroduction of endangered plants.* eds D.A. Falk, C.I. Millar, M. Olwell, pp. 171–207. Island Press, Washington, DC.
- Hamilton, M.B., 1994. *Ex situ* conservation of wild plant species: time to reassess the genetic assumptions and implications of seed banks. *Conservation Biology* 8, 39–49.
- Havens, K., Kramer, A.T., Guerrant, E.O., 2014. Getting plant conservation right (or not): the case of the United States. *International Journal of Plant Sciences* 175, 3–10.
- Helm, A., Zobel, M., Moles, A.T., Szava-Kovats, R., Pärtel, M., 2015. Characteristic and derived diversity: implementing the species pool concept to quantify conservation condition of habitats. *Diversity and Distributions* 21, 711–721.
- Herranz, J.M., Ferrandis, P., Martínez-Duro, E., 2010. Seed germination ecology of the threatened endemic Iberian *Delphinium fissum* subsp. *sordidum* (Ranunculaceae). *Plant Ecology* 211, 89–106.
- Heywood, V.H., 2016. In situ conservation of plant species – an unattainable goal? *Israel Journal of Plant Sciences* 63, 211–231.
- Heywood, V.H., 2017. Plant conservation in the Anthropocene – challenges and future prospects. *Plant Diversity* 39, 314–330.
- Heywood, V.H., 2019. Conserving plants within and beyond protected areas – still problematic and future uncertain. *Plant Diversity* 41, 36–49.
- Hobbs, R.J., Arico, S., Aronson, J., Baron, J.S., Bridgewater, P., Cramer, V.A., Epstein, P.R., Ewel, J.J., Klink, C.A., Lugo, A.E., Norton, D., Ojima, D., Richardson, D.M., Sanderson, E.W., Valladares, F., Vila, M., Zamora, R., Zobel, M., 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography* 15, 1–7.
- Hobbs, R.J., Higgs, E., Harris, J.A., 2009. Novel ecosystems: implications for conservation and restoration. *Trends in Ecology & Evolution* 24, 599–605.
- Hobbs, R.J., Higgs, E.S., Hall, C.M. eds., 2013. *Novel ecosystems: intervening in the new ecological world order.* Wiley-Blackwell, Oxford, UK.
- Howe, H.F., Martínez-Garza, C., 2014. Restoration as experiment. *Botanical Sciences* 92, 459–468.
- Iturriaga, L., Jordan, M., Roveraro, C., Goreux, A., 1994. In vitro culture of *Sophora toromiro* (Papilionaceae), an endangered species. *Plant Cell Tissue and Organ Culture* 37, 201–204.
- Kay, J., Strader, A.A., Murphy, V., Nghiem-Phu, L., Calonje, M., Griffith, M.P., 2011. Palma corcho: A case study in botanic garden conservation horticulture and economics. *Horttechnology* 21, 474–481.
- Kelly, C.K., Smith, H.B., Buckley, Y.M., Carter, R., Franco, M., Johnson, W., Jones, T., May, B., Ishiwaru, R.P., Perez-Jimenez, A., Magallanes, A.S., Steers, H., Waterman, C., 2001. Investigations in commonness and rarity: a comparative analysis of

- co-occurring, congeneric Mexican trees. *Ecology Letters* 4, 618-627.
- Koch, C., Kollmann, J., 2012. Clonal re-introduction of endangered plant species: The case of German false tamarisk in pre-Alpine rivers. *Environmental Management* 50, 217-225.
- Lu, Y., Ranjitkar, S., Xu, J.-C., Ou, X.-K., Zhou, Y.-Z., Ye, J.-F., Wu, X.-F., Weyerhaeuser, H., He, J., 2016. Propagation of native tree species to restore subtropical evergreen broad-leaved forests in SW China. *Forests* 7, 12.
- Maunder, M., 1992. Plant reintroduction – an overview. *Biodiversity and Conservation* 1, 51-61.
- Maunder, M., Hughes, C., Hawkins, J.A., Culham, A., 2004. Hybridization in ex situ plant collections: conservation concerns, liabilities, and opportunities, In *Ex situ plant conservation: Supporting species survival in the wild*. eds E.O.J. Guerant, K. Havens, M. Maunder, pp. 325-364. Island Press Washington, DC.
- Maxted, N., Ford-Lloyd, B.V., Hawkes, J.G., 1997. Complementary conservation strategies, In *Plant genetic conservation, the in situ approach*. eds N. Maxted, B.V. Ford-Lloyd, J.G. Hawkes. Chapman and Hall, London.
- Millet, J., Tran, N., Ngoc, N.V., Thi, T.T., Prat, D., 2013. Enrichment planting of native species for biodiversity conservation in a logged tree plantation in Vietnam. *New Forests* 44, 369-383.
- Morgan, J.W., 1999. Have tubestock plantings successfully established populations of rare grassland species into reintroduction sites in western Victoria? *Biological Conservation* 89, 235-243.
- Partel, M., Szava-Kovats, R., Zobel, M., 2011. Dark diversity: shedding light on absent species. *Trends in Ecology & Evolution* 26, 124-128.
- Possiel, W., Saunier, R.E., Meganck, R.A., 1995. Chapter 2 – in-situ conservation of biodiversity, In *Conservation of biodiversity and the new regional planning*. eds R.E. Saunier, R.A. Meganck. Organization of American States and the IUCN – The World Conservation Union. Department of Regional Development and Environment Executive Secretariat for Economic and Social Affairs General Secretariat, Organization of American States.
- Radeloff, V.C., Williams, J.W., Bateman, B.L., Burke, K.D., Carter, S.K., Childress, E.S., Cromwell, K.J., Gratton, C., Hasley, A.O., Kraemer, B.M., Latzka, A.W., Marin-Spiotta, E., Meine, C.D., Munoz, S.E., Neeson, T.M., Pidgeon, A.M., Rissman, A.R., Rivera, R.J., Szymanski, L.M., Usinowicz, J., 2015. The rise of novelty in ecosystems. *Ecological Applications* 25, 2051-2068.
- Ratnamhin, A., Elliott, S., Wangpakapattananawong, P., 2011. Vegetative propagation of rare tree species for forest restoration. *Chiang Mai Journal of Science* 38, 306-310.
- Rodrigues, R.R., Gandolfi, S., Nave, A.G., Aronson, J., Barreto, T.E., Vidal, C.Y., Brancalion, P.H.S., 2011. Large-scale ecological restoration of high-diversity tropical forests in SE Brazil. *Forest Ecology and Management* 261, 1605-1613.
- Sakai, C., Subiakto, A., Nuroniah, H.S., Kamata, N., Nakamura, K., 2002. Mass propagation method from the cutting of three dipterocarp species. *Journal of Forest Research* 7, 73-80.
- Schneider, T., Ashton, M.S., Montagnini, F., Milan, P.P., 2014. Growth performance of sixty tree species in smallholder reforestation trials on Leyte, Philippines. *New Forests* 45, 83-96.
- Schoen, D.J., Brown, A.D.H., 2001. The conservation of wild plant species in seed banks. *BioScience* 51, 960-966.
- Seddon, P.J., Armstrong, D.P., Maloney, R.F., 2007. Developing the science of reintroduction biology. *Conservation Biology* 21, 303-312.



- Shono, K., Davies, S.J., Chua, Y.K., 2007. Performance of 45 native tree species on degraded lands in Singapore. *Journal of Tropical Forest Science* 19, 25-34.
- Simmons, J.B., Beyer, R.I., Brandham, P.E., Lucas, G.L., Parry, V.T.H. eds., 1976. *Conservation of Threatened Plants*. Plenum Pub Corp, New York and London.
- Subiakto, A., Rachmat, H.H., Sakai, C., 2016. Choosing native tree species for establishing man-made forest: A new perspective for sustainable forest management in changing world. *Biodiversitas Journal of Biological Diversity* 17.
- Volis, S., 2016a. Conservation-oriented restoration – how to make it a success? *Israel Journal of Plant Sciences* 63, 276-296.
- Volis, S., 2016b. Conservation meets restoration – rescuing threatened plant species by restoring their environments and restoring environments using threatened plant species. *Israel Journal of Plant Sciences* 63, 262-275.
- Volis, S., 2016c. How to conserve threatened Chinese species with extremely small populations? *Plant Diversity* 38, 53-62.
- Volis, S., 2016d. Species-targeted plant conservation: time for conceptual integration. *Israel Journal of Plant Sciences* 63, 232-249.
- Volis, S., 2018. Plant conservation in the Anthropocene: Definitely not win-win but maybe not lose-lose?, In *Reference Module in Earth Systems and Environmental Sciences*. eds D.A. DellaSala, M.I. Goldstein, pp. 389-397. Elsevier, Oxford.
- Volis, S., 2019. Conservation-oriented restoration – a two for one method to restore both threatened species and their habitats. *Plant Diversity* 41, 50-58.
- Volis, S., Blecher, M., 2010. Quasi in situ – a bridge between ex situ and in situ conservation of plants. *Biodiversity and Conservation* 19, 2441-2454.
- Williams, J.W., Jackson, S.T., 2007. Novel climates, no-analog communities, and ecological surprises. *Frontiers in Ecology and Environment* 5, 475-482.
- Young, T.P., 2000. Restoration ecology and conservation biology. *Biological Conservation* 92, 73-83.

## **ERICA VERTICILLATA, FROM EXTINCTION TO RESTORATION**

ANTHONY HITCHCOCK\*

### **Abstract**

The Threatened Species Programme at the South African National Biodiversity Institute (SANBI), Kirstenbosch National Botanical Garden, is integrated to include both ex situ and in situ conservation activities. Plant conservation is driven by South Africa's Strategy for Plant Conservation which was developed in response to the Global Strategy for Plant Conservation. This case study examines the conservation of *Erica verticillata* (whorl heath), a flagship for threatened species at Kirstenbosch, and documents the integration of ex situ within situ conservation at three areas on the Cape Flats. The whorl heath was thought to be extinct by 1950. Horticulturists have since rediscovered nine clones in botanic gardens worldwide, the Heather Society, and commercial growers. Ex situ conservation in botanic garden collections and the Millennium Seed Bank has since allowed in situ conservation in the critically endangered Cape Flats Sand Fynbos vegetation type. The process of restoring the whorl heath presented many challenges. Initially attempts were hampered by limited available knowledge on suitable niche habitats. Pioneering work carried out at Rondevlei Nature Reserve identified the suitable habitat and this was applied in subsequent in situ work at Kenilworth Racecourse Conservation Area and at Tokai Park – the only natural areas remaining in or near this species' historical distribution range. Successful re-establishment of this species depends upon its capacity to recruit after fire, which is an essential ecological process in the fynbos. Many clones have been in cultivation for a long time and are poor seed producers: Seed production was first recorded at Rondevlei only after additional clones were planted together. Only one population (Rondevlei) to date has seen a fire and thus has recruited seedlings; however, these are competing with vigorous companion plants. The study continues and is currently exploring the role of herbivory in the restoration process. The key lesson learnt to date is the need to include sustainable manage-

\* Kirstenbosch National Botanical Gardens, SANBI, South Africa.

ment of the entire ecosystem in the restoration process and not limit it to single species. Success in restoring a species depends upon a healthy stand of the vegetation type in place, along with pollinators and other key fauna and other natural ecosystem processes. It is recommended that successful re-establishment of a species in fynbos requires the reintroduced population to survive three fire cycles.

### **Forerunner**

The Kirstenbosch conservation programme in the 1970s and 1980s was pioneered by Curator John Winter and focussed on establishing collections of threatened species in pots in the Kirstenbosch Collections Nursery. Each collection was established and cared for by horticulturists dedicated to specific target families such as Proteaceae and Ericaceae. While this initiative is to be commended it was severely limited due to space and inability to preserve enough gene pool in pot collections. In most cases, threatened species collections were soon reduced to single clones through attrition with little conservation value and in all too frequent instances lost altogether.

In 2002, the author was appointed to the position of Nursery and Living Collections Manager which included responsibility for threatened species. The limitations of conservation pot collections and the need to revise the conservation programme were identified. To this purpose, a new conservation strategy was developed for Kirstenbosch. This comprised an integrated approach to include ex situ and in situ conservation activities. The focus was placed on sound genetic-based ex situ conservation collections and, where possible, in situ restoration at secure and ecologically sustainable natural area reserves. Fortuitously, the South African National Biodiversity Institute (SANBI) signed an agreement with the Royal Botanic Gardens, Kew in 2000 to become a partner and contributor to the Millennium Seed Bank Project. From this time, the primary ex situ collections were housed in seed banks and these were augmented by collections in dedicated threatened species stock beds and pots. The latter were used as source material for restoration projects mainly on Cape Flats Sand Fynbos (CFSF) where a critical need was identified to conserve the vegetation type and the ecosystem therein. Thereafter, the conservation strategy led by Kirstenbosch evolved beyond simple species conservation to include sustainable habitat and ecosystem conservation and management. Naturally, this required partnerships with other conservation organizations, primarily the Environmental Resource Management Department (ERMD) for the

City of Cape Town and the South African National Parks. Some years later, SANBI was tasked to develop South Africa's response to the Global Strategy for Plant Conservation. Numerous researchers were included from within SANBI and other academic and conservation organizations to develop South Africa's Strategy for Plant Conservation (SASPC). This was completed and endorsed by the Minister of Environmental Affairs in 2015. The relevant South African target pertinent to this paper is based on the GSPC with amendments decided upon at the workshops.

GSPC: Target 8: *At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes*

SASPC: Target 8: *At least 60% of threatened plants in ex situ collections, preferably in the country of origin, and available for recovery (restoration) programmes, with 1% in active reintroduction programme.*

The South African Strategy amended the global targets to what was decided to be manageable in South Africa bearing in mind the large numbers of threatened species and capacity available. The target of 20% available for recovery and restoration programmes was deemed too ambitious in the South African context and possibly meaningless since plants 'available for restoration' is not equal to them being in active restoration. One percent was decided upon based on the number of species already in in-situ conservation and the considerable resources and expertise required to manage this. Additionally, Kirstenbosch was also the only Botanical Garden in SANBI doing in situ conservation.

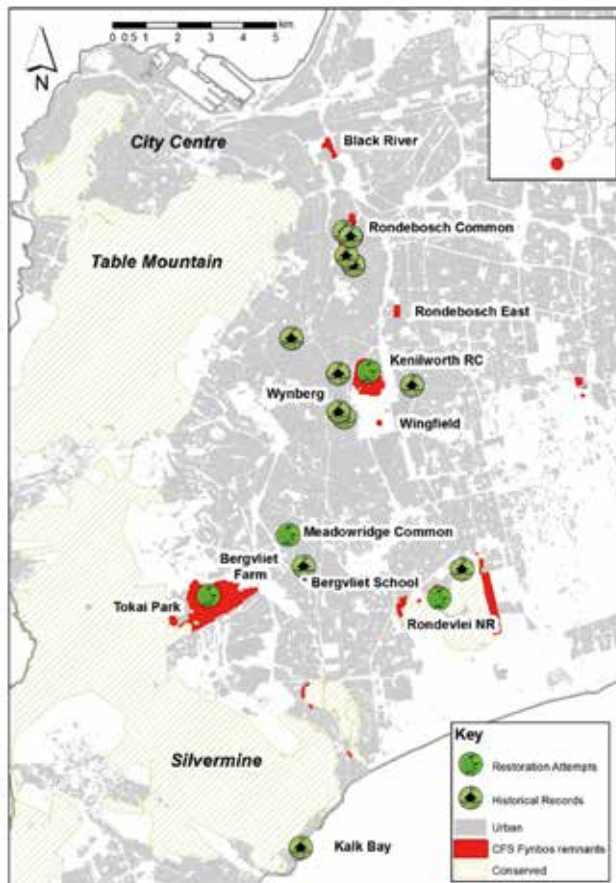
The following case study examines the integrated approach to conserving *Erica verticillata* (whorl heath), and documents ex situ conservation at Kirstenbosch and in situ conservation at three areas on the Cape Flats.

## Introduction

*Erica verticillata* is a flagship for threatened species at Kirstenbosch and in SANBI and is unique in the annals of plant conservation in South Africa (Hitchcock, 2003). Its recovery and restoration is an interesting case study and may provide useful lessons in plant conservation. It is a beautiful, sturdy species growing to between 1.5–2 m in height, but old specimens have been recorded to be up to 3 m tall. It produces beautiful maroon or light pink, tubular flowers arranged in neat whorls organized in distinct groups up the principal stems and near the tips of sturdy branches. Peak flowering is from January to March, but plants produce some flowers intermittently throughout the year. The flowers attract sunbirds, bumblebees, hawk

moths, bees, and beetles that come to sip the nectar the flowers provide as reward to pollinators. The specific epithet, from the word ‘verticillatus’, is descriptive of the whorled (verticillate) arrangement of the flowers.

It used to grow in Cape Flats Sand Fynbos (CFSF) on the lowlands of the Cape Peninsula from the Black River to Zeekoeivlei (Oliver & Oliver, 2000). Herbarium records indicate that it grew in a narrow, 3 km-wide corridor between the main road and the M5 freeway from the Black River cottages near Mowbray in the north, at Rondebosch, Newlands, Claremont and Kenilworth as far as Wynberg (Figure 14.1). A single, isolated record from Kalk Bay (Thompson, 170 in PRE) might be suspect. The



**Figure 14.1.** Map showing the historical distribution and restoration locations of *Erica verticillata* on the Cape Flats, Cape Town. Source: Map drawn by Anthony Rebelo; used with the permission of *Sibbaldia*.

written record suggests that it may have occurred as far south as Zeekoeivlei (Adamson & Salter, 1950).

The rather superficial information on herbarium sheets and in the literature suggests that this species preferred seasonally damp, acid, sandy soils near rivers and wetlands. Agricultural and urban development that occurred as Cape Town expanded resulted in the destruction of its natural habitat. It is an attractive plant with long flowering stems and was regularly sold as a cut flower, being one of the few plant species to flower in profusion during the mid-summer (January–March) months (Gibbs, 2014). The last herbarium specimen collected from the wild dates to 1908 and was collected by Dümmer (Dümmer, 210 in NBG). More recent herbarium records in South Africa are specimens of plants growing at Kirstenbosch in 1943 (Henderson, 1669 in NBG) and from a cultivated plant growing in the Pretoria district (Repton, 5698 in PRE). The whorl heath also appears on the Bergvliet Primary School badge (Hilton–Taylor, 1996b).

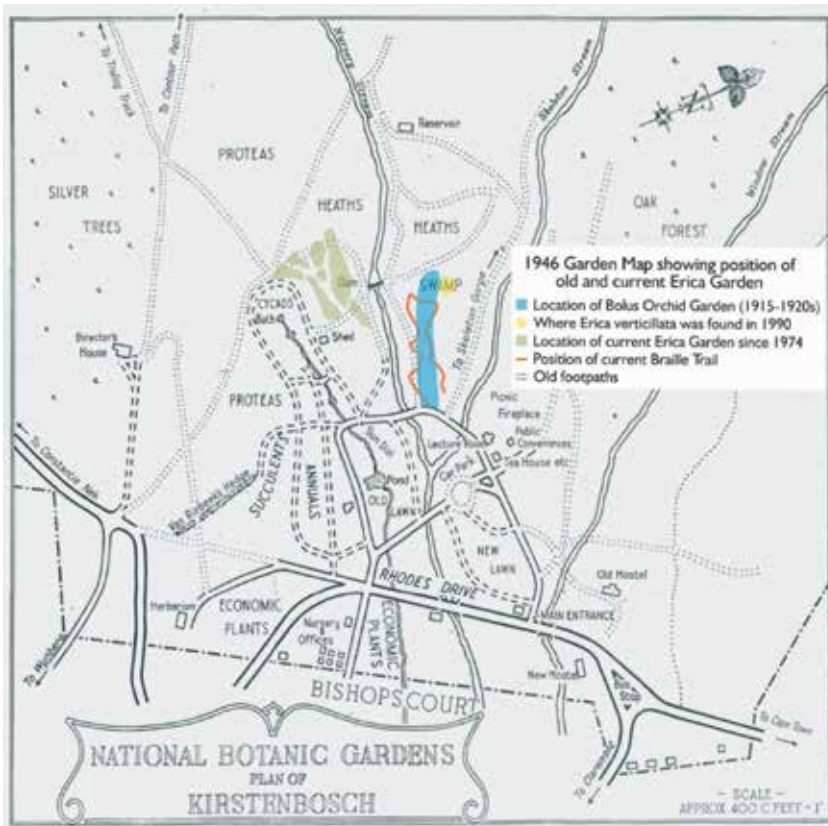
After the Second World War, an entirely new suburb of Cape Town was established to provide accommodation for ex-servicemen. The Bergvliet Housing Scheme attracted many young families and soon a modern primary school was built in 1949 ready for the first term of 1950 (Bergvliet Primary School, 2013). The school chose the whorl heath as the focal point of its badge because it was a very popular plant common in the Bergvliet area until about 1948. It was regarded as possibly extinct in the wild by 1950 (Adamson & Salter, 1950) and was listed extinct in 1996 (Hilton Taylor, 1996a). Hilton Taylor classified a species to be extinct if it was not found in its natural habitat after repeated searches. This category was also used for a taxon that no longer occurs in the wild but survives in at least one form in cultivation or in a seed bank. Contemporary classifications record it as extinct in the wild (Raimondo *et al.*, 2009).

### **The recovery of *Erica verticillata***

During the early 1980s, the Kirstenbosch Erica horticulturist, Deon Kotze, was actively searching for and establishing pot collections of threatened ericas (Hitchcock, 2003). His attempts to find remnant populations of *Erica verticillata* in the few remaining Cape flats habitats in the southern suburbs of Cape Town were unsuccessful. Fortunately, the 1984 Kirstenbosch Scholar, Dawid von Well, recognized the species from herbarium specimens and brought back flowering samples and cutting material from Erica plants growing at Jan Cilliers Park, also known as Protea Park, in Groenkloof, Pretoria. Collections of fynbos were established in Protea

Park during the 1960s by Curator J.E. Repton (Grobler, 2013). This was most probably the same as the specimen lodged in the herbarium by Repton in 1961 (Repton 5698 in PRE). It was confirmed as *Erica verticillata* by Dr. E.G.H. Oliver and propagated for the collection. A few years later, a mature stand of this species was discovered by the Kirstenbosch Head Foreman, Adonis Adonis, growing in a derelict bed behind the Braille Trail.

It is assumed that the specimen growing at Kirstenbosch and lodged in the herbarium by Henderson (Henderson 1669 in NBG) originates from the Louisa Bolus collection made in 1917 because it is the only record of this species being collected from habitat in the Kirstenbosch Garden plant



**Figure 14.2.** Map showing the location of the Bolus Orchid Garden and where the *Erica verticillata* plants were discovered in 1990. Source: Map discovered in the archives from Members of the Botanic Society.

records. Furthermore, there is a 1920 record of planting ericas that like wet habitats in the Harry Bolus Orchid Garden to provide some shade protection to the ground orchids. The Bolus Orchid Garden was situated where the Braille Trail exists today and where the old *Erica verticillata* plants were found (Figure 14.2).

In addition to accession numbers, registered cultivar names were given by the British Heather Society to each collection to distinguish them from one another (see Appendix). There are subtle differences between each cultivar such as flower colour, corolla tube length and density of flower arrangement, size of plant, and density of foliage. These differences are also evident on the herbarium collections.

The Pretoria collection was named ‘African Phoenix’ and the Kirstenbosch collection was given two cultivar names to distinguish the dark pink form, ‘Adonis’, from the light pink form ‘Louisa Bolus’. The latter cultivar honours Louisa Bolus, the first Curator of the Bolus Herbarium, who made the first and only wild collection of the whorl heath for Kirstenbosch. She is recorded to have collected seed from the Wynberg Flats on 1 May 1917 (Hitchcock, pers. obs.).

The search for lost collections of the whorl heath was continued by the author in 2000 and was an exercise in detective work. The existence of additional collections was revealed with assistance from Dr. Oliver, members of the British and American Heather Societies, botanic gardens, Erica growers in Europe, and internet searches. Through this process, collections were added from the following: Belvedere Palace Garden in Vienna – ‘Belvedere’; Tresco Abbey Gardens on the Scilly Isles – ‘Tresco Abbey’; the private Erica collection of ‘Doctor Violet Gray’ via the British Heather Society – ‘Doctor Violet Gray’; Monrovia Nursery in California – ‘Cherise’; the Royal Botanic Gardens, Kew (RBG, Kew) – ‘Harry Wood’. More recently, another form has been identified. This specimen comes from a small market garden nursery, Heidegartnerei Grunberg in Dresden, which is specialized in Erica. It was being sold at a market in East Berlin. This was bought by Erica nurseryman Helmut Heidl and passed on to Kirstenbosch. It was given the registered name, ‘Dresden’. Nine confirmed collections have been found to date all of which have been allocated cultivar names by the British Heather Society (Appendix 1). The author is currently investigating the origin of another distinct form supplied by Helmut Heidl which may well be the tenth form recovered. Four of the cultivars, ‘African Phoenix’, ‘Adonis’, ‘Louisa Bolus’, and ‘Belvedere’ have been used in restoration programmes (Hitchcock, 2013; Grobler, 2013).



The role of the Belvedere Palace Garden in conserving Cape ericas and threatened species goes back a long way and is unsurpassed in botanic gardens' history. Belvedere Gardens is part of a group of botanical gardens and parks in Vienna that collectively fall under Österreichische Bundesgärten (Austrian Federal Gardens) and include the famous Schönbrunn Gardens. Two gardeners, Francis Boos and George Scholl, were responsible for many plant collections made in the Cape between 1786 and 1799 for Emperor Joseph II of Austria (Gunn & Codd, 1981). Boos was evidently the leader of the expedition. He was a botanist as well as a gardener whereas Scholl was a working gardener with little scientific knowledge. Emperor Joseph II sent them to make collections of tropical plants from Mauritius, but bad weather forced their ship to shelter at the Cape of Good Hope and their stay turned out to be longer than planned (Nelson & Oliver, 2004). They made numerous collections of South African plants and even went on a brief collecting trip with Francis Masson (Gunn & Codd, 1981). Boos stayed at the Cape for a year and then went on to Mauritius leaving Scholl behind to continue collecting. Boos returned to the Cape in 1788 and stayed for only a few months before returning to Vienna in July 1788 with a large collection of specimens and living plants. Scholl stayed at the Cape for twelve years mainly because he could not get passage on a ship that would transport his plant collections. Scholl was aided in the Cape by Colonel Robert Jacob Gordon, Commandant of the Dutch Garrison at the Cape. Gordon gave him protection, assisted him with his field excursions and allowed him to grow his plants in his garden, often referred to in literature as 'the Gordon's Garden', which was situated on what is now Prince Street in the suburb known as Gardens (Garside, 1942; Gunn & Codd, 1981). Many plants were established here, and Scholl collected seed from them. From time to time, Scholl sent shipments of dried bulbs and seeds to Vienna, of which four shipments are recorded in the Cape Archives from 1790 to 1792. They were first shipped to the Austrian Consul in Holland who had them transported up the Rhine and then overland to Vienna. Scholl was finally able to return to Vienna in 1799 taking with him a large collection of living plants and seed, including species of *Erica*. Scholl was rewarded for his efforts by being promoted to the post of Superintendent to the Gardens of the Belvedere Palace (Garside, 1942). Staff at the Austrian Federal Gardens believe that the ericas at the Belvedere Palace Garden date back to the Boos and Scholl collections, as there is no evidence of other collections being made. Michael Knaack, Head of the Department of Botanical Collections at Belvedere, asked his prede-

cessor who had been working in the gardens since the 1930s for further information on this issue. He remembered the collections manager before him saying that the collection had always been there. Therefore, the erica collection dates at least as far back as the nineteenth century and therefore quite conceivably originates from the Boos and Scholl collections. The Belvedere collections has representatives of various Cape Proteaceae and at least 67 ericas of which two are extinct in the wild, two critically endangered, three endangered, two vulnerable and three rare.

These original collections at Belvedere Palace Gardens appear to have been nurtured for over 200 years through all the political turmoil of wars and conquest. Some members of the Heather Society of Great Britain doubt that these collections could have survived the ravages of war and particularly the bombing at the end of the Second World War. Indeed, most of the collections at Belvedere were destroyed at the end of the war when the glasshouses were damaged by a bomb falling in the centre of the Reservegarten. Many plant collections survived however, because they were purposely duplicated and moved to other gardens and glasshouses, so it was possible to reduce the risk and to save most of the species. The erica collection was evidently moved to the Alpengarten (Alpine Garden) where there is an Erdhaus (earth house). An earth house is a house where earth is used as an additional building material for a significant proportion of the covering of the wall or ceiling construction. In the earth house, the earth acts as an insulating layer that protects against cold, rain and wind. This is apparently how the erica collection survived the last winter of the Second World War in Vienna.

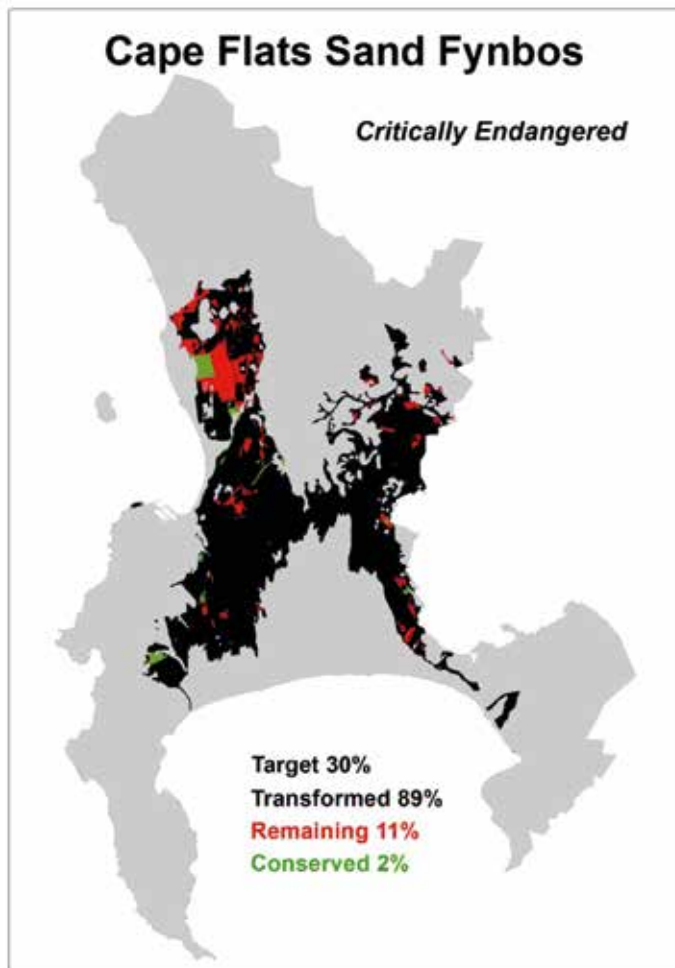
## Conservation

There is much debate and some scepticism within the community of botanic gardens and academic, conservation and botanical research organisations over the conservation value of keeping collections of wild species in botanic gardens or at private growers (Cadman, 2016). However, experience with the whorl heath demonstrate that maintenance of a conservation collection can play an important role in the preservation of a species and may in some cases contribute to conservation programmes, at least for charismatic species.

The best way to conserve a species is in its natural habitat where it is subject to natural ecological systems (Hitchcock et al., 2012). The Cape Town area is 2460 km<sup>2</sup> in extent and has 19 vegetation types, 6 of which are endemic, 10 are critically endangered, 3 are endangered and 4 are vulnerable. There are 3250 plant species in the core Cape Town area of which

450 species are threatened and included in the Red List: 49 of these are locally extinct and 13 are globally extinct, the greatest number for any city in the world (Holmes et al., 2012).

Restoration of many threatened species on the lowlands of the Western Cape is complicated by the fact that most threatened species occur in threatened habitats that are often small, fragmented and compromised by edge effect. *Erica verticillata* occurs in the Cape Flats Sand Fynbos (CFSF) vegetation type, which is classified as critically endangered (Figure 14.3).



**Figure 14.3.** Map showing the status of Cape Flats Sand Fynbos in 2017. Source: Map drawn by Anthony Rebelo and Amalia Pugnalin.

Humans have damaged and destroyed over 85% of CFSF due to urban expansion of the City of Cape Town with more than half of this occurring in the last 50 years, and the vegetation type has over 110 threatened Red List plant species (Raimondo et al., 2009).

The South African National Conservation Target for the CFSF vegetation type is 30% (Mucina & Rutherford, 2006). The amount left has declined from 16% in 2009 (Stipinovich & Holmes, 2009) to 13.4% in 2016 of which only 2% are conserved in nature reserves, while half of this is degraded and in poor condition (Holmes & Pugnalin, 2016). As of 2017, only 11% CFSF remains, of which only 4% can be considered natural vegetation and potentially restorable, with the remainder being highly degraded (i.e. unploughed, but there is a legacy effect of alien vegetation having altered the ecosystem quite radically). Alien woody species such as *Acacia saligna* invade fynbos and, in most cases, form dense, impenetrable stands which dominate and replace the natural vegetation. They drastically change the natural community structure causing the reduction in species diversity and water resources. They increase the fuel loads that result in too many intensely hot fires, which are detrimental to the recruitment of many fynbos species. Acacias produce large numbers of hard-coated seeds that are long-lived and germinate in profusion after fire and outcompete natural vegetation (P. Holmes, pers. comm.). The remnants of this vegetation type are severely fragmented and most conserved areas – Rondevlei Reserve (9.2ha), Meadowridge Common (6.0ha) and Rondebosch East Common (5.1ha) – are too small to provide viable habitats. There are only two areas large enough for restoration, namely Blaauwberg Nature Reserve and Tokai Park. Rondebosch Common and Youngsfield are too transformed and Kenilworth Racecourse Conservation Area<sup>1</sup> (42ha) is privately owned without any official conservation status. Attempts to establish a conservation management agreement with the racecourse owners have not succeeded to date (Hitchcock et al., 2008). The abovementioned status of CFSF illustrates the dire situation when attempting to restore threatened species to their natural, historical habitat.

### **Restoration programmes for *Erica verticillata***

The rediscovery of the whorl heath excited interest amongst some conservationists to re-establish it in its natural habitat. Three restoration attempts were undertaken at three sites between 1994 and 2008. These in-

<sup>1</sup> [www.krca.co.za](http://www.krca.co.za)

clude Rondevlei in the False Bay Nature Reserve, Kenilworth Racecourse Conservation Area (KRCA) and at the Tokai Section of Table Mountain National Park. These were the only areas within or near the species' natural historical range where it was possible and suitable to undertake restoration.

### **Rondevlei Nature Reserve**

Dalton Gibbs, Conservation Manager for the City of Cape Town, made the first attempts to reintroduce the whorl heath at Rondevlei Nature Reserve in 1994. The challenge was to discover a suitable place for planting, as so little habitat information was recorded, other than that it occurred "near moist areas". He planted 20 specimens of the cultivar 'African Phoenix' grown in 1kg bags supplied by Kirstenbosch, in a transect starting at the drier sandy areas across a range of habitats ending in the wetland. Only one plant survived in the intermediate, moist area, indicating that this species might prefer the marginal areas between the dry and wet soils. More were planted in 1995, 1997, and 1998 (Hitchcock, 2003). These established well, reaching maturity and attracting several pollinators, including *Cinnyris chalybeus subsp. chalybeus* (southern double-collared sunbird), Lepidoptera: Sphingidae (hawk moths) and Xylocopa spp. (carpenter bees). Despite this, they did not produce seed, and it was concluded that the clone 'African Phoenix' was self-sterile. In 2001, two more clones, 'Adonis' and 'Louisa Bolus', were planted at pollination distance to each other to enable seed production. These additional clones were successful in setting viable seed. Seed was collected and germinated in the Rondevlei nursery in 2005 (Wilman, pers. comm.) The first ecological fire – a prescribed burn – was put through the population of 150 plants on the 27th March 2013. The fire behaviour observed at Rondevlei suggests that this species has an unexpected strategy of suppressing fire and a complementary flowering strategy to ensure survival. When fire passes through the population, the plants burst into flame as the leaves torch up and then, unexpectedly, the fire subsides, leaving behind relatively unscathed plants. The fire incinerates the flammable leaves but burnt skeletons of branches appear to be fire-resistant, remaining intact, unlike the companion species which are burnt to the ground. The dead plants clearly mark out where the ericas once stood, perhaps providing semi-shade and wind protection for the seedlings. It is also suggested that restricting the seed to the original distribution may be essential to this species which has ecotonal habitat requirements (Gibbs, 2014).

It is assumed that the flowering strategy of *Erica verticillata* is as follows. It flowers from mid-summer to early autumn (January to April) which is

the fire season in fynbos. Successive whorls of flowers are produced. When the first set of flowers mature the next set is in bud. There are often three groups of flowers arranged up the stem. Fires normally occur in late summer by which time the first seed capsules have matured, while the second set is still flowering. The seed is retained in protective capsules, which open within a few hours of the fire, scattering seeds beneath the skeletal parent plant. It has been observed that recruiting seedlings survive better where they are given protection from the elements by nurse plants. In the absence of fire, the seeds are released when ripe at the end of summer. The first record of post-fire recruitment of *Erica verticillata* from seed was observed in 2015 (Gibbs, pers. comm., 2015).

The seedlings had to contend with vigorous regrowth from competing plants such as *Stenotaphrum secundatum* (H. Walter) Kuntze (Buffalo Grass) and *Psoralea pinnata* L. (Fountain Bush). It is difficult to be sure, but it appears that seedlings might have been overwhelmed by competing plants. This demonstrates that a functioning ecosystem is critical to the success of restoration programmes. The role of herbivory in controlling competition at Rondevlei is being studied through a pilot project to reintroduce eland (*Tragelaphus oryx*) (Cape Times, 2015). This project started in 2016 and initial observations are positive: eland are selective in what they browse, feeding on grass and woody vegetation, but ignoring the *Erica* plants (Cape Times, 2015).

### **Kenilworth Racecourse Conservation Area (KRCA)**

The site is regarded as the best and least disturbed example of CFSF remaining on the southern suburbs of Cape Town.<sup>2</sup> In 2004, 100 plants comprising 3 clones, 50 'African Phoenix', 25 'Adonis' and 25 'Louisa Bolus', were planted within 100m of each other at Kenilworth (KRCA) in a seasonally wet depression. Young plants in 1kg bags, propagated from cuttings, were planted in mature vegetation to protect them from the summer heat and wind. Eighty per cent of these plants survived and have flowered profusely every year. Seedling recruitment has been observed in open patches near the parent plants. Cape Nature organized a controlled burn in an adjacent section of the KRCA in March 2005. A second population was established in a moist area adjacent to the east. Plants grown in 50cc re-usable plastic Unigrow® propagation plugs, and in 1kg bags, were planted in mid-winter, June 2005 (Hitchcock, 2006). The plants from plugs all died

<sup>2</sup> [www.krca.co.za](http://www.krca.co.za)

during the summer, probably because they were too exposed to the desiccating summer winds and heat. Thirty per cent of the plants grown in 1kg bags planted amongst grasses survived. It is surmised that the plants in bags survived better because they were protected by re-sprouting grasses that were growing in situ. It has been observed that 'nurse plants' shelter young plants from desiccating summer wind and by partially shading the plants, keeping them cooler and in better condition. It is speculated that plants grown in plugs do not have enough root mass to support the young plants through the first summer whereas those in larger containers have a larger root mass to sustain them. This is based on monitoring other young plants in restoration where 1kg container plants survived better than those planted from plugs, although the surviving plug-grown plants outperformed the plants grown in 1kg bags in the long term.

### **Tokai Park**

This site, which has been under pine plantations for the past 100 years, is now being managed to protect and conserve its endangered vegetation type CFSE. Most of the restoration at Tokai is passive, relying on natural regeneration after felling the pines and a restorative fire to flush the seed bank. However, several species designated as extinct or critically endangered (Raimondo et al., 2009) have been reintroduced. This is the case with *Erica verticillata* for which a reintroduction programme began at Tokai in 2004 managed by Kirstenbosch, South African National Parks and the Millennium Seed Bank Project. The first planting took place in the Soetvlei wetland which was recovering after clearing (Hitchcock & September, 2016). The plants grew well but were being chewed down to ground level by *Otomys irroratus* (African vlei rat) and swamped by vigorous wetland plants, such as *Cyperus* spp. (Sedges). A new site higher on the slope was identified where competing plants were less likely to swamp the young ericas. The area was also more exposed, which we hoped would allow predators such as raptors to control the rodents. Further rodent control involved the relocation of snake species *Pseudaspis cana* (mole snakes) and *Bitis arietans* (puff adders) which had been rescued from adjacent residences and stables. The ericas established splendidly, with the aid of predators or not, and have become a feature admired by visitors to Tokai Park.

The most extensive planting to date of 5,000 plants of whorl heath was planned along the Prinskasteel wetlands in 2008. The wetlands are bordered by pine plantations, but there was enough natural area to make an

experimental planting along the southern fringe of the wetlands stretching for 200m (September, 2010). Three clones, ‘Adonis’, ‘Belvedere’ and ‘African Phoenix’, were selected as the best seed producers (Grobler, 2013). Sunbirds are common in the area so we hoped that they would pollinate and result in the formation of a significant seed bank. The planting was done in rows, 1m apart comprising 15, 10 and 15 plants of the 3 clones respectively. The rows were perpendicular to the stream edge from the water’s edge into the dry areas. The restoration of the whorl erica in the wetlands was more successful than anticipated despite the gradient where some plants were planted in drier areas. There was one instance of careless herbicide application when subcontractors controlling invasive *Rubus* also sprayed some of the ericas, killing 20 per cent of plants – the total mortality was 40 per cent. This, together with other challenges such as fire belts being cut through the restoration stands, highlights the need for coordinated management, efficient communication and knowledgeable supervision. The plants survived best in the marginal zone between dry and wet and grew to be larger and more robust on the wetter end. Plants which were further from the wetland were smaller, and most of the plants in the driest zone died. The vigorous plants in the wet marshy areas did less well, being overwhelmed by wetland species. ‘Belvedere’ did not do as well as the other two clones, being smaller and less robust when planted. The experiment showed that even though some sedges outcompeted the whorl heath in the wettest habitat, and aliens did so in others, the restoration was still comprehensive and extensive over the area. The variety of pollinators visiting the ericas was astounding, with far more pollinators than just the birds which had been expected to be attracted by the blossoms. Apart from *Anthobaphes violacea* (orange-breasted sunbird) and *Cinnyris chalybeus* (southern double collar sunbird), other visitors noted included wasps (Hymenoptera), carpenter bees, Cape honeybees (*Apis mellifera subsp. capensis*), hawk moths, and some small beetles. Subsequently, plantings have been made along the Prinskasteel canal, and in two other wetlands at Tokai, with the whorl heath establishing far better than most other species attempted, perhaps because wetlands buffer against the summer droughts (which have been particularly severe recently) better than the drier sands typical of sand fynbos. This is corroborated by the fact that a planting outside of the wetlands was a total failure. Restoration at Tokai is a finely balanced process and the public were asked to keep out of the restoration areas to allow the recovery process to develop with as little human impact as possible. However, promoting awareness is crit-



ical and the public must be informed. This is in line with Target 14 of the GSPC: “*The importance of plant diversity and the need for its conservation incorporated into communication, educational and public-awareness programmes*” (Convention on Biological Diversity, 2010; Raimondo, 2015). SANParks and the Friends of Tokai Park (a public volunteer group affiliated with the Wildlife Society of South Africa (WESSA)) selected an area between two of the entrances where some of the threatened species could be planted to showcase the restoration work at Tokai. Funding was provided by the Old Mutual Two Oceans Marathon via the Table Mountain Park Honorary Rangers. The area is called the Tokai Restoration Trail and includes interpretation boards explaining the restoration process, reasons and the management plans. The trail was designed by a local landscape architect and includes pathways and a boardwalk over the wet areas. A range of CFSF species are planted, ten of which have threatened status: extinct in the wild, critically endangered, endangered, and vulnerable. The trail was planted by Tokai Park staff, Friends of Tokai Park, Kirstenbosch National Botanic Garden, and Millennium Seed Bank staff, and was opened by Park Manager Paddy Gordon in September 2013.

### **Lessons learned when restoring Cape Flats Sand Fynbos**

Fynbos is a fire-adapted ecosystem requiring periodic burning. In the absence of fire, fynbos is gradually outcompeted by woody coppicing species such as *Searsia lucida*. Fynbos thrives on infertile soils and fire is the mechanism by which senescent plant material is removed and nutrients are recycled into the soil. Fire is a crucial trigger that resets the ‘successional clock’. It provides the stimulus for dormant seeds to germinate and the opportunity for many annuals, short-lived perennials and bulbs to grow, flower and set seed during times of abundant nutrients and sunlight. They complete their short life cycles, returning to the soil as larger shrubs overwhelm them, and remain dormant until the next fire. The optimal fire cycle for fynbos is 10–20 years (Kraaij & Van Wilgen, 2014). Shorter fire cycles can wipe out slow-maturing species, while other species start dying when intervals become too long. Restoration of fynbos species needs to include fire in the management protocol. To determine when the project to restore the whorl heath to the wild may be considered successful is problematic. IUCN Red List rules state that reintroduced plants must produce viable offspring before they can be counted as mature individuals (IUCN Standards and Petitions Subcommittee, 2016). In other words, after two generations, all flowering plants which are producing seed can

be counted as mature individuals and used in the population assessments. *Erica verticillata* has self-incompatible clones so in this case the viability of the F1 generation must be checked before assessing the success of the species in the restoration project. In most cases the second natural generation after planting would qualify as a success, but in the case of the whorl heath, it is suggested that a third generation is required in order to ensure that the F1 is fertile and sustainable. In addition, given the threats of recruitment competition from natural and alien species in a habitat recovering from disturbance which includes pine plantations, root disturbance by dune moles, excessive herbivory or lack thereof and variances in climate, it is recommended that successful re-establishment of a species in fynbos requires the reintroduced population to survive three fire cycles. In order to down list *Erica verticillata* from 'extinct in the wild', an assessment will have to be made of the number of plants that exist after three generations; whether the population is stable, declining or increasing; how fragmented the populations are; and the level of conservation protection afforded to the areas of restoration.

## Conclusion

Several lessons have been learned in the process of restoring *Erica verticillata* and many of these are pertinent to active species restoration on CFSF. The ex situ conservation approach alone is insufficient and therefore an integrated approach including in situ conservation is essential if possible. Restoration of a species on its own is not good enough. A sustainable restoration programme needs to include restoration and sustainable management of the remaining ecosystem, which in this case includes fire. Success in restoring a species depends upon a healthy stand of the vegetation type being in place, along with pollinators and other animals and soil fauna and flora required for maintaining the system. If this is not in place, steps must be taken to restore the missing components. Any imbalance in this system, such as an explosion in the population of vlei rats, as happened in Tokai Park, might result in one component becoming a problem rather than having a beneficial influence. The destructive and positive role of herbivory needs to be explored further as this might be a crucial factor in success or failure (Cape Times, 2015). Finally, the entire system must be managed holistically, with fire belts and alien control programmes incorporated into areas targeted for species-specific restoration. Conservation of the rich Cape flora is an enormous challenge, particularly given the increased demand for land and resources, and the effects of climate change. This is especially true

of the Cape lowlands and CFSF where *Erica verticillata* originates. At the time of writing, large numbers of plants are on the brink of extinction on the Cape lowlands. We will lose these species, and many more, unless these endangered habitats are conserved as a matter of urgency. *Erica verticillata* therefore plays a crucial role as a flagship species to create an awareness of the general plight of our vanishing flora within the City of Cape Town and beyond.

*Erica verticillata* is one example of many attempts to conserve and restore threatened species under the direction of the GSPC. Yet the survival of this species, despite more than 35 years of concentrated efforts to bring it back from the brink of extinction, is uncertain. The weakest link is that the existing clones are only housed at Kirstenbosch National Botanical Gardens. Since April 2018 there has been no dedicated horticulturist looking after the Kirstenbosch *Erica* collection. A recent visit to the collection with molecular systematists in March 2019 revealed that already one of the clones is incorrectly labelled and more than 50% of *Ericas* in the pot collection are unlabelled. The survival of Botanical Gardens *ex situ* pot collections depends upon good and continuous curation. Efforts are being made by the author with assistance from Cape Town conservation staff, *Erica* researchers and other botanical gardens to establish backup collections in Europe and in the City Conservation nursery under MOUs.

The critically endangered status of CFSF vegetation type is another serious threat. The horseracing industry in South Africa is depressed and there are repeated attempts by the owners of the Kenilworth Racecourse Conservation Area to develop the natural areas in efforts to maximize profits. There have been attempts by Cape Nature to get the owners of Kenilworth Racecourse to sign a MOU to declare the central natural area a Section 23 Nature Reserve under the Protected Areas Act. While negotiations are still in process development proposals are being made including draining the area for underground parking and providing services to the conservation area. If they get approval to drain the area the whole conservation area will be compromised.

The Tokai Park is also under threat. Even though it has been handed over to SANParks for restoration and management there is considerable public pressure from a group called Parkscape who are demanding the retention of the remnant pine plantations and thereafter rotational replanting of pine trees to keep the area shaded for their recreation. This despite the forestry company having declared the area uneconomical for plantations (Figure 14.4).



**Figure 14-4.** 'Transitional Area' planting for shaded recreational landscape within the Tokai and Cecilia Management Framework 2005-2025. Source: South African National Parks and Table Mountain National Park (2009).

In terms of the threats to *E. verticillata* and other CFSF species the current and increasing trend of land invasions around Cape Town poses a risk to these systems. Alien vegetation, although controlled in many areas, continues to be a long-term threat, especially *Acacia saligna* (Port Jackson) which has an enduring seed bank.

Another threat to these systems is the expertise and passion which is needed to sustain them into the future. Dalton Gibbs, senior manager for Environmental Resource Management Department (ERMD) for the City of Cape Town, is not convinced that there are sufficiently trained and motivated conservation staff to sustain specialised habitat types such as CFSF (Gibbs, D., pers. com).

Fortunately, seed of *Erica verticillata* has been harvested and banked at the MSBP, but only from two parents. There is scope for further conservation work and research on this species. Dr. Mike Pirie, specialist in organic, molecular and evolutionary botany focussing on *Erica*, is keen to sequence the available clones to investigate them further as part of ongoing conservation research.

### **Acknowledgment**

The author acknowledges *Sibbaldia*<sup>3</sup> as the primary source for this paper.

<sup>3</sup> More specifically, the corresponding article by Hitchcock & Rebelo (2017) published in *Sibbaldia: The International Journal of Botanic Garden Horticulture*, 17:101-120. The Royal Botanic Garden Edinburgh, Edinburgh. Accessible at: <https://journals.rbge.org.uk/index.php/rbgesib/article/view/222>

## Bibliography

- Adamson, R.S. & Salter, T.M. (1950). Flora of the Cape Peninsula. Juta & Co., Ltd., Cape Town and Johannesburg.
- Bergvliet Primary School (2013). History. Available online (accessed July 2017): <http://bergvlietprimary.co.za/index.php/about-us/history>
- Cadman, M. (ed.) (2016). Fynbos Forum Ecosystem Guidelines for Environmental Assessment (2nd edn), Chapter 4, pp. 60–78. Available online (accessed July 2017): [http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/04/Ecosystem\\_Guidelines\\_Ed2.pdf](http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/04/Ecosystem_Guidelines_Ed2.pdf)
- Cape Times (2015). Three-year Gantouw Pilot Project will reintroduce eland to the Cape Flats. 23 November, p. 3.
- Convention On Biological Diversity (2010). Updated Global Strategy for Plant Conservation 2011–2020. Available online (accessed June 2017): [www.cbd.int/gspc](http://www.cbd.int/gspc)
- Garside, S. 1942. Baron Jacquin and the Schönbrunn Gardens. *Journal of South African Botany* 8: 201–224.
- Gibbs, D. (2014). Baptism of Fire. *Veld & Flora*, 100(1), 30–32.
- Grobler, A. (ed.) (2013). *Erica verticillata* Ericaceae. *Flowering Plants of Africa*, 63, 104–119.
- Gunn, M. & Codd, L.E. 1981. Botanical exploration of Southern Africa. Balkema, Cape Town.
- Hilton-Taylor, C. (1996a). Red Data List of Southern African Plants. *Strelitzia*, 4. National Botanical Institute, Pretoria.
- Hilton-Taylor, C. (1996b). Threatened Ericaceae in southern Africa. *Yearbook of the Heather Society*, 7–16.
- Hitchcock, A. (2003). *Erica verticillata* is brought back from the brink of extinction. *Yearbook of the Heather Society*, 45–50.
- Hitchcock, A. (2006). Restoration Conservation at Kirstenbosch. *Veld & Flora*, 92(1), 40–44.
- Hitchcock, A. (2013). *Erica verticillata* P.J. Bergius (Ericaceae). *PlantZAfrica*. Available online (accessed June 2017): <http://pza.sanbi.org/erica-verticillata>
- Hitchcock, A. & Rebelo, A.G. (2017). The Restoration of *Erica verticillata* – a Case Study in Species and Habitat Restoration and Implications for the Cape Flora. *Sibbaldia*, 15, 39–63.
- Hitchcock, A. & September, J. (2016). Kirstenbosch Threatened Species Programme: Tokai Rehabilitation Project. Unpublished Report.
- Holmes, P. & Pugnalin, A. (2016). The Biodiversity Network for the City of Cape Town Municipal Area. C Plan & Marxan Analysis: 2016 Methods and Results. Environmental Resource Management Department (ERMD), City of Cape Town, June 2016. Available online (accessed October 2019): [http://conservationcorridor.org/cpb/Holmes\\_and\\_Pugnalin\\_2016.pdf](http://conservationcorridor.org/cpb/Holmes_and_Pugnalin_2016.pdf)
- Holmes, P.M., Rebelo, A.G., Dorse, C. & Wood, J. (2012). Can Cape Town's unique biodiversity be saved? Balancing conservation imperatives and development needs. *Ecology and Society*, 17(2), 28. Available online (accessed June 2017): <http://dx.doi.org/10.5751/ES-04552-170228>
- IUCN Standards And Petitions Subcommittee (2016). Guidelines for Using the IUCN Red List Categories and Criteria. Version 12. Available online to download (accessed March 2017): [www.ucnredlist.org/documents/RedListGuidelines.pdf](http://www.ucnredlist.org/documents/RedListGuidelines.pdf)
- Kraaij, T. & Van Wilgen, B. (2014). Drivers, ecology and management of fire in fynbos. In Allsopp, N., Colville, J.F. & Verboom, G.A. *Fynbos: Ecology, Evolution and Conservation of a Megadiverse Region*. Oxford University Press, Oxford.
- Mucina, L. & Rutherford, M.C. (2006). *The Vegetation Map of South Africa, Lesotho and Swaziland*. SANBI, Pretoria.
- Nelson, E.C. & Oliver, E.G.H. 2004. Cape heaths in European gardens: the early history of South African *Erica* species in cultiva-

- tion, their deliberate hybridization and the orthographic bedlam. *Bothalia* 34: 127-140.
- Oliver, I. & Oliver, E.G.H. (2000). *Field Guide to the Ericas of the Cape Peninsula*. Protea Atlas Project, National Botanical Institute, Cape Town.
- Raimondo, D. (ed.) (2015). *South Africa's Strategy for Plant Conservation*. South African National Biodiversity Institute and the Botanical Society of South Africa, Pretoria.
- Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. & Manyama, P.A. (2009). *Red List of South African Plants*. *Strelitzia* 25. South African National Biodiversity Institute, Pretoria.
- September, J. (2010). A felling tale. Restoring critically endangered lowland fynbos in the Tokai Plantation. *Veld & Flora*, 96(3), 134-135.
- South African National Parks & Table Mountain National Park (2009). *Tokai and Cecilia Management Framework 2005-2025*. Last accessed on November 20, 2019, at [https://www.sanparks.org/docs/parks\\_table\\_mountain/library/2009/final\\_tokai\\_cecilia\\_MF\\_report.pdf](https://www.sanparks.org/docs/parks_table_mountain/library/2009/final_tokai_cecilia_MF_report.pdf)
- Stipinovich, A. & Holmes, P. (2009). *City of Cape Town's Biodiversity Network. C-Plan & Marxan Analysis: 2009 Methods and Results*. Environmental Resource Management Department (ERMD), City of Cape Town, December 2009. Available online (accessed June 2016): [http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/BioNet\\_Analysis-2009\\_Methods+Results\\_report\\_2009-12.pdf](http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/BioNet_Analysis-2009_Methods+Results_report_2009-12.pdf)

## Appendix

**Table 14.1.** *Erica verticillata* clones registered by the Heather Society. Charity no. 261407. Address: 84 Kinross Road, Rushington, Totton, Southampton, SO40 9BN, UK for Kirstenbosch National Botanical Garden.

<i>Erica verticillata</i> cultivar name	Cultivar reg. no.	Accession number at Kirstenbosch	Origin
'Adonis'	E.2012:06	273/2012	Kirstenbosch Estate, South Africa. Discovered by foreman Mr A. Adonis probably from original collection by Mrs. Louisa Bolus in 1917
'African Phoenix'	E.2012:05	536/1984	Jan Cilliers Park (Protea Park), Pretoria, South Africa
'Belvedere'	E.2012:07	109/2001	Österreichische Bundesgärten (Austrian Federal Gardens), Belvedere Palace Nursery, Vienna, Austria. Probably originating from collections by Francis Boos and George Scholl, 1786-1799
'Cherise'	E.2012:11	549/2006	Monrovia Nursery, California, USA
'Doctor Violet Gray'	E.2012:09	548/2006	From the collection of Dr. Violet Gray, original member of the Heather Society Cape Heaths Group, UK
'Harry Wood'	E.2012:10	657/2006	Harry Wood, Curator of the Fernkloof Nature Reserve, Hermanus, South Africa sent seed to the Royal Botanic Gardens, Kew in 1961. Accession number 1961-9001. Then sent to Kirstenbosch NBG in 2006
'Louisa Bolus'	E.2012:12	272/2012	Kirstenbosch Estate, South Africa. Discovered by foreman Mr A. Adonis probably from original collection by Mrs Louisa Bolus in 1917
'Tresco Abbey'	E.2012:08	543/2006	Tresco Abbey Botanic Garden, UK
'Dresden'	DME 2018-06	14/2012	This specimen comes from a small market garden nursery, Heidegartnerei Grunberg in Dresden, specializing in Erica. Donated to Kirstenbosch by Helmut Heidl <a href="http://www.hiedl-gbr.de">http://www.hiedl-gbr.de</a>
<i>Source:</i> All the clones were registered on 4 September 2012 by Anthony Hitchcock.			



## TECHNOLOGIES FROM AGRICULTURE TO HELP “NOAH” SAVE PLANTS

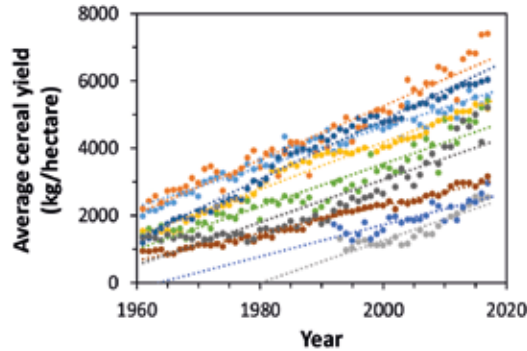
CHRISTINA WALTERS\*

### The agricultural context

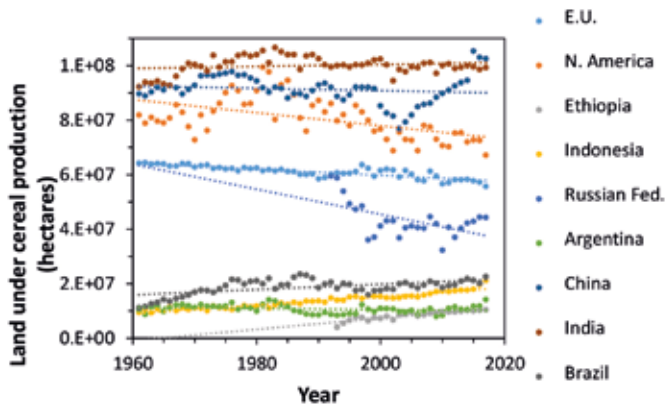
A nexus of food, water, and energy security is rapidly approaching. More than one third of Earth’s land (1.6 billion hectares) is under cultivation and more than 70% of its fresh water is used for agriculture (FAO, 2011). Land use for cultivation ranges among countries from over 80% (i.e, Uruguay, Saudi Arabia, and Kazakhstan) to less than 4% (i.e., mostly island nations, but also Greenland, Norway, and Egypt) (Worldbank, 2019). FAO (2011) reports large disparities among countries in terms of sustainable agricultural practices, resulting in 25% of the world’s land being highly degraded and no longer productive. A warmer, wetter planet, as many are predicting, may mean longer growing season and higher agricultural productivity; but these conditions also promise changes to the virulence of crop diseases and pests in complex and unanticipated ways (Velásquez et al., 2018), further threatening food security. Agriculture is surely part of the problem, and must be part of the solution.

The encouraging news is that agriculture is rapidly changing in an effort to ease human suffering as well as impact on the environment. The ‘Green Revolution’ philosophy, begun in the 1960s, focuses on technological advancement in agriculture to increase crop productivity by integrating sciences on genetic resources, fertilizer, and pesticides. As a result, the amount of land needed to support a person is decreasing – from 0.45 hectares/yr in 1961 to 0.22 hectares/yr in 2006 (FAO, 2011). This remarkable statistic arises from increased yields – an average of 42 kg/hectare/yr for cereals worldwide (Figure 15.1), with many of the more industrialized countries enjoying double that yearly increase (Worldbank, 2019). As a result, more lands are going into production in some countries to increase food independence while other countries are taking land out of production (Figure 15.2). These shifts in land use create opportunity.

\* USDA-ARS National Laboratory for Genetic Resources Preservation, Fort Collins, CO USA. christina.walters@ars.usda.gov



**Figure 15.1.** Average yield of cereal grains (a world development indicator) since 1960 in countries with high agricultural land use. *Source:* <http://datatopics.worldbank.org/world-development-indicators/themes/environment.html>



**Figure 15.2.** Land under cereal production since 1960 in countries with high agricultural land use. *Source:* Data from Worldbank, world development indicators, updated 24 Apr 2019 (visited 5 May 2019).

Many, if not all, the yield advancements since the 1960s (Figure 15.1) can be attributed to genetic resources of crop species. “Noah” and the speakers at the conference on species protection at the Pontifical Academy of Sciences (May 13–14, 2019) focused on ‘conservation targets’ at the species or taxonomic level (*sensu* Soulé, 1991). However, in agriculture, our conservation focus is at the population or even individual genotype level, usually to collect genetic resources that provide nature’s solutions to agri-

cultural problems such as yield, disease resistance, drought tolerance, flavor and a host of other problems that can crop up. Hence, agriculturally-based genebanks are large in terms of number of accessions (accessions are the unique elements that comprise collections, often it is a bag of about 3,000 seed with unique identifying information), but usually small in terms of number of species included. For example, USDA's collection is called the National Plant Germplasm System (NPGS) and currently includes about 600,000 unique accessions from about 16,000 species.<sup>1</sup> The strategy is to ensure that we have captured the genetic diversity of crops so that rare genes controlling important traits are available. For example, genes for resistance to Russian wheat aphid (*Diuraphis noxia*) were found within NPGS's collection of about 55,000 unique accessions of wheat or its wild relative *Aegilops*. Plant breeders found eleven accessions with resistance to this pest, collected from the former Soviet Union and Tajikistan, where *Diuraphis noxia* originates and landraces of *Triticum aestivum* exist (Byrne et al., 2018).

The idea of collecting and preserving genetic resources *ex situ* for the purposes of crop enhancement is credited to the Russian botanist, Nikolai Vavilov (1887-1943), who introduced the concept of 'Centers of Diversity' for agronomic species, linking diversity, domestication and early human civilizations (Vavilov, 1987). Vavilov's ideas on genetics and inheritance were considered subversive in Stalinist Russia, and so he was imprisoned and died of starvation – ironically, since his research was dedicated to feeding the world's people.

Plants were regularly introduced to the "New World" by immigrants. In the US, formal Plant Introductions (PI) began after the Civil War when USDA was formed. The first official Plant Introduction (PI #1) is a cabbage from Siberia collected in 1898. Efforts to catalog, preserve and regenerate seeds of Plant Introductions – rather than letting them die in uncontrolled storage environments – began after World War II. This period also marks the beginning of modern-day cryobiology because of the chance discovery that spermatozoa treated with glycerol survived exposure to liquid nitrogen (Polge et al., 1949). Seeds from crops do not require additions of glycerol, or other cryoprotectants, to survive genebanking conditions. They have the remarkable capacity to survive drying, and so, unlike most biological organs and tissues, seeds can be placed in a regular freezer (-20°C) and avoid lethal ice formation. The simplicity of the storage technology made genebanking seeds accessible to any group

<sup>1</sup> <https://npgsweb.ars-grin.gov/gringlobal/query/summary.aspx> visited 6 May 2019.

with reliable refrigeration. USDA’s National Seed Storage Laboratory (now NLGRP) was established in 1958. Since then, genebanks storing seeds have proliferated from a handful in the 1970s to about 1750 in 2012, serving agriculture, conservation, and studies of ecology, evolution, and diversity (Hay and Probert, 2013; FAO, 2014).

We could consider plant genebanks as ‘arks,’ human constructs to protect plant species (or populations) from catastrophe such as a metaphorical flood. Plant genebanks that spin a ‘doomsday’ scenario get good publicity and public accolades. For agriculture, doomsday would be an admission of failure to produce enough food in spite of constant pressure from pathogens, pests, inclement weather, and degraded soils. So, I do not view genebanks as arks that hunker down and escape tough times. Rather, genebanks are the exact tools needed to get us through tough times, every day. They are working libraries, sharing knowledge about our biological world and providing insight about diversity, how to respect and sustainably use diversity, and consequences for humanity if we do not. In my opinion, the biggest challenge to us (and Noah) is not building an ark or loading it up. It is the ‘exit plan,’ that is, ensuring that the collected materials eventually get off the ark.

### **Loading up the Ark – What do we choose to collect and curate?**

China’s recent experiment to sprout seeds on the moon<sup>2</sup> suggests that the ark concept need not be restricted to Earth. From artists’ renderings, we might envision Noah’s ark to be a collection of reproductive individuals that need constant care and sustenance to ensure proliferation. These “living” collections (*sensu* Soulé, 1991) require large spaces and significant human investment in husbandry. The amount of diversity that can be concentrated is directly related to the volume occupied by individuals in combination with the amount of resources required to maintain each individual.

For plants, a living collection may be an orchard or botanical garden that grows a subset of individuals from a species or population. This is critical work to understand the growth habits and characteristics of the plant. A scientific collection is useless without these data. However, living collections are at risk from inclement weather, pests, pathogens, social unrest, and aging individuals that eventually become post-reproductive.

<sup>2</sup> <https://www.the-scientist.com/news-opinion/china-is-growing-cotton-on-the-moon-65321>

Genetic erosion through drift, inadvertent selection, or introgression with neighboring related plants can also occur while growing or regenerating a sample. Living collections are also required to regenerate the sample, but regeneration can be expensive especially for large plants that may take years to sexually mature. The approach requires high investment in labor and land, and the return is a living specimen which is an exemplar of the species. If the goal is to keep the last remaining individuals of a species alive, this strategy buys some time.

An alternative to living collections are ‘quiescent’ collections that hold germplasm from organisms in a state of suspended animation. Germplasm is a small part of the organism (perhaps a single cell in the case of sperm or pollen) that carries genetic information or that can be grown into another individual. A quiescent collection exchanges the benefit of viewing a living, growing specimen for the benefit of capturing greater diversity in a compact space. Currently, NLGRP stores its collection of nearly 750,000 accessions of 3,000 seeds each in a 90x30x3 m space, essentially allowing about 3 million individuals per m<sup>3</sup>. These individuals must be stored so that viability is maintained, but they cannot be allowed to grow (discussed below). Selecting germplasm (i.e., propagules) for quiescent collections in a plant genebank requires optimization of survival to preservation stresses, processing time and cost per storage volume. Costs of processing and storage should figure significantly into the genebank’s business model to determine the volume of material that can be managed effectively.

Fortunately, plants are fairly plastic in their reproductive behavior and plant genebanks have options on the propagule that embodies a pre-defined conservation target. For plants, conservation targets can be at several biological scales such as a population, an individual (or genotype), a trait, or even a particular allele (gene variant). The propagules that house the desired feature of diversity must be amenable to storage in a quiescent collection (Table 15.1). Seeds are the most commonly used propagule for plant genebanks. Usually compact, plentiful, storable, growable, and representative of maternal and pollen-donor lines, seeds might just be the ideal medium for plant genebanking. Most seeds have innate abilities to survive extreme drying and low temperature without adding cryoprotectants (Walters, 2015).

**Table 15.1.** Some common propagules used in plant genebanks.

propagule	advantages	disadvantages	exceptions
Seeds: conservation target at population and/ gene level	<ul style="list-style-type: none"> <li>• compact</li> <li>• high fecundity of some plants make it possible to collect many individuals</li> <li>• highly developed, low-cost, storage technology for orthodox seeds</li> <li>• efficient for propagation &amp; regeneration &amp; distribution</li> <li>• represents progeny of extant population (can capture many genotypes and many genes)</li> <li>• may present barrier to some diseases</li> <li>• demonstrated ability to efficiently capture diversity</li> </ul>	<ul style="list-style-type: none"> <li>• heterogeneous traits in wild populations; multiple harvest times needed and timing can be unpredictable</li> <li>• asynchronous germination can lead to poor stand establishment and drift</li> <li>• long time to sexual maturity in perennials</li> <li>• potentially unknown pollen source</li> <li>• mating systems may preclude maintaining desired maternal traits</li> </ul>	<ul style="list-style-type: none"> <li>• non-orthodox seeds require cryogenic storage</li> <li>• possible low seed production in wild due to reproductive failure (endangered species), drought, late frost, non-mast year, herbivory</li> </ul>
Pollen: conservation target at gene level	<ul style="list-style-type: none"> <li>• very compact</li> <li>• available for immediate use in breeding programs</li> <li>• available during flowering</li> <li>• amenable to storage</li> <li>• captures diverse genes</li> <li>• maybe the fastest, least labor-intensive way to achieve some form of back-up</li> </ul>	<ul style="list-style-type: none"> <li>• a gamete, not an individual</li> <li>• ephemeral</li> <li>• difficult to harvest</li> <li>• must make crosses to regenerate populations</li> <li>• must be genebanked immediately after collection (short processing timeline)</li> </ul>	
Shoot tips: conservation target at individual level	<ul style="list-style-type: none"> <li>• compact</li> <li>• captures specific genotype; OK as an exemplar of species</li> <li>• amenable to in vitro culture</li> <li>• preservation technologies rapidly developing</li> <li>• clonal propagation reduces concern about genetic drift</li> </ul>	<ul style="list-style-type: none"> <li>• requires large amounts of quality source materials at correct phenological stage</li> <li>• unexplained variation in response to growth medium among genotypes</li> <li>• unexplained variation in response to growth medium among genotypes</li> <li>• processing and growth is labor-intensive</li> <li>• many individuals needed to capture diversity of a heterogeneous population</li> </ul>	

propagule	advantages	disadvantages	exceptions
Dormant buds or overwintering vegetative structures: conservation target at individual level	<ul style="list-style-type: none"> <li>• compact</li> <li>• captures specific genotype; OK as an exemplar of species</li> <li>• does not require in vitro culture (less labor than shoot tips)</li> <li>• preservation technologies are advancing</li> <li>• clonal propagation reduces concern about genetic drift</li> <li>• recovered by grafting</li> </ul>	<ul style="list-style-type: none"> <li>• plants must be winter-adapted and in acclimated state</li> <li>• recovered by grafting</li> <li>• many individuals needed to capture diversity of a heterogeneous population</li> </ul>	<ul style="list-style-type: none"> <li>• variable responses within and among species result from complex bud structures</li> </ul>
Somatic embryos and cell cultures: conservation target at individual level	<ul style="list-style-type: none"> <li>• compact</li> <li>• captures specific genotype;</li> <li>• may be more amenable to preservation than non-orthodox seed</li> <li>• can generate huge numbers of individuals</li> </ul>	<ul style="list-style-type: none"> <li>• successful propagation is highly genotype-specific; tends to narrow captured diversity</li> <li>• high risk of soma-clonal variation</li> <li>• labor intensive for establishing and processing</li> </ul>	

*Note:* See also Havens et al. (2004) for complementary information. *Source:* Walters et al. (2018)

Pollen is under-appreciated as a germplasm form in plants, which contrasts with animal genebanks in which semen, the counterpart to pollen, is the most commonly used germplasm form (Mazur et al., 2008). Pollen might be an effective alternative germplasm form that can capture genes of interest and deliver them to a breeding population when seeds are unavailable or have poor storage characteristics or when maintaining cuttings is cost-prohibitive. For example, pollen from oak trees is desiccation tolerant, while oak seeds tend to be recalcitrant (Franchi et al., 2011; Walters et al., 2013). Pollen is storable, but it lacks the longevity traits exhibited in seeds of the most common agronomic species (Dafni and Firmage, 2000).

Plant genebanks frequently distinguish between propagules that are sexually-derived (i.e., seeds and pollen) and those that arise from vegetative cuttings (i.e., clonally propagated). In agriculture, this distinction usually occurs because the conservation target is a specific genotype and the plant is highly heterozygous and outcrossing. For example, a genetically identical potato plant (a clone) can be regenerated from the “eye” of a potato. Clonal propagation may be necessary for plants of conservation concern if

there is reproductive failure in the wild (e.g., inbreeding, no pollinators) or if population sizes are inviable (Pence, 2013). Cloning the few remaining individuals to increase demographics (but not necessarily genetic diversity) has led to successful reintroductions.

There will always be plants that appear intractable to genebanking until research finds a way. A whole class of seeds, described as ‘recalcitrant,’ were deemed impossible to store in the 1980s (Walters et al., 2013); but methods are developing to allow routine storage, albeit in liquid nitrogen. The most difficult materials for NLGRP are currently avocado (*Persea americana*) because it appears resistant to an in vitro recovery system and sugarcane (*Saccharum officinarum*) because it is riddled with endophytes and appears to lose totipotency with age of culture stock. Eliminating roadblocks for avocado is urgent as the species, like all members within Lauraceae in North and Central America, is threatened by the fungal pathogen *Raffaelea lauricola*, responsible for laurel wilt disease that is spread by the redbay ambrosia beetle (*Xyleborus glabratus*) (Kendra et al., 2013). These stories exemplify the shifting priorities of loading up an ark: save what is feasible; what is most vulnerable; what we value most?

### **Life on the Ark – Repository biology to aid *ex situ* conservation**

Because of its early interests in seed biology, agriculture has made large contributions to the technological know-how for *ex situ* banking of plant genetic resources. “Orthodox” seeds, by virtue of their innate ability to survive drying, naturally achieve a state of suspended animation in which they are alive, but do not appear to be living – at least by most of our criteria of what living systems do: i.e., metabolize, grow and respond to the environment. The transition from living and growing to quiescent in seeds is associated with the change in their cells from water-based and fluid to dry and solid (Walters et al., 2010). During embryogenesis, seeds pack their cells with food reserves to provide the foundation and reinforcement for structure while concomitantly removing water.

The stabilization achieved by solidifying cytoplasm is perhaps more intuitively understood by looking at the technologies used to make plastics, stabilize dry foods and ensure that the drugs stored in our medicine cabinets deliver constant dosages up to the expiration date. These types of solids are often referred to as ‘glasses’, in which the molecular organization is irregular. In the other type of solid, which we learned about in grade school, molecules are organized in a regular pattern to form a crystal, e.g., when liquid water freezes and turns to ice. The irregular molecular struc-



ture can form rather discreetly, with no discrete change in molecular structure; hence it can be quite survivable as long as the mechanical shock of shrinkage as cells lose water is avoided (Walters, 2015). Once formed, the solid can be further stabilized by lowering the temperature. The absence of water and slowed molecular motion within a solid makes lethal ice highly unlikely in orthodox seeds, and so freezer storage (also called “conventional” storage) is a standard approach to prolong viability cost effectively.

Vegetative propagules and some non-orthodox seeds (unfairly referred to as “recalcitrant”) do not survive cell shrinkage during the drying process needed to solidify cytoplasm at room temperature (Table 15.1). Hence, we must engineer other methods to vitrify the cytoplasm while maintaining cell viability. Cryogenic storage for plant germplasm became accepted in the mid-1980s and routine in the mid-1990s. Successful cryopreservation involves optimization of interacting factors such as moisture, cryoprotectants and exposure rates to and from liquid nitrogen temperatures (Walters et al., 2013). There are still many species for which preservation protocols do not currently exist. This is not because we do not understand the basic principles of preservation. Rather it points out that we cannot expect diverse materials to respond to standardized treatments the same way – there is always some ‘tweaking’ that has to be done to achieve initial survival. With time and sufficient materials to experiment with, workable methods are available for an increasingly huge array of plant propagules to facilitate preservation of plant diversity *ex situ*. The issue is whether the current pace, set by the number of scientists working on the problem, is sufficient to meet the urgent need as water rises around the ark.

Time slows down in preserved cytoplasm, but it does not stop. The irregular structure in solidifying cytoplasm, that saved the cells initially, allows some movement to occur. As the molecules move, the cytoplasm ages. So, we must not be lulled into a false sense of security when germplasm initially survives our treatments. For most materials, survival times are long (at least 50 years), but we are observing faster than expected aging in some germplasm, such as fern spores and pollen, even at liquid nitrogen temperatures (Ballesteros et al., 2018).

The aging of quiescent germplasm during storage can seem counter-intuitive, but research in a number of apparently-unrelated disciplines is elucidating the mechanisms of change in non-crystalline solids (such as solidified cytoplasm) that eventually cause loss of function. Everyday examples include yellowing of paper, brittleness of rubber and plastics, and lost flavor in dried foods past the expiration date. For preserved germplasm,

lost function usually equates to lost viability, and this occurs abruptly and without warning during storage. This is partly because only viability assays are currently available and we need to revive the germplasm (because it is quiescent) to detect aliveness. However, the inevitability that quiescent germplasm ages embodies the profound reality that chemical and physical reactions are constant degradative forces on organic matter, bringing truth to precepts that what is alive eventually returns to dust (Genesis 3:19).

It is hard to predict when the alive–dead discontinuity will occur and the constant testing for viability in quiescent germplasm consumes materials. Yet without knowing when germplasm succumbs in storage, we will not know when to use it or to regenerate it. All the effort of preserving germplasm *ex situ* will be for naught if it dies in the genebank. Therefore, we have sought to understand aging and to develop tools that indicate progress before mortality. At writing, our most successful assay monitors integrity of RNA, a class of molecules that are intermediaries between DNA (genes) and proteins (cell machinery) (Fleming et al., 2018). Based on this work, and other assays that inform about structural or biochemical changes within the solidified cytoplasm, we envision aging of preserved germplasm as a straw-that-broke-the-camel’s-back process, with many small random reactions that damage any molecule within the cell, culminating in a major effect.

The increasing number of anecdotal accounts that seeds collected from the wild are harder to store are not surprising (Hay and Probert, 2013; Walters, 2015; Ballesteros and Pence, 2017). We know that plant embryo development is critical to longevity and metabolic pathways expressed during embryogenesis are key (Righetti et al., 2015; Walters, 2015). Seed quality is dependent on processes that are uncontrolled in the wild during the growing season, such as moisture availability, nutrition, competition and pathogens, and it will decline if developmental programs are not completed or extended towards germination. Phenology, fecundity, carbon partitioning, composition, seed coverings, resistance to pests and drought tolerance are all inherited traits that affect seed longevity. These traits are more uniform in domesticated plants, but vary considerably in seeds from natural populations; hence, an accession of seeds collected from the wild will be heterogeneous and this will result in differences in how individual seeds within the sample respond to genebanking conditions. One of genebanking’s major challenges is preventing domestication in wild germplasm placed under highly controlled conditions. Genebanks must preserve the wildness so that the species can eventually leave the ark.

## Exiting the Ark – Benefits from plant germplasm collections

The proliferation of plant germplasm banks around the world (to more than 1700 in 2019) attests to human confidence that our ingenuity and respect for natural diversity can forestall its attrition in the face of uncertainty about the future and increasing human pressure on habitats. Moreover, this investment conveys the understanding that human fate is inextricably connected to the fate of species that also share the Earth.

Technologies to preserve diversity *ex situ* are becoming increasingly sophisticated, but they lack purpose if there is no plan beyond stockpiling germplasm. Hence, an ‘exit plan’ is essential to realize the benefits of investing in genebanking. Such a plan can be fraught with ethical and moral dilemmas. For example, a question during the conference in response to this paper’s technology update focused on countries’ ownership of genetic resources used in agriculture. Additionally, conservation groups worry about re-introducing a plant once its habitat is lost. The emerging technologies cannot address these, and many other issues, but they can ‘buy time’ needed for discussion. Genebanking technologies provide an available and practical strategy to temporarily forestall the rapid loss of plant biodiversity on Earth.

## Bibliography

- Ballesteros, D. and Pence, V.C. 2017. Survival and death of seeds during liquid nitrogen storage: a case study on seeds with short lifespans. *CryoLetters*, 38(4): 278–289.
- Ballesteros, D., Hill, L.M., Lynch, R.T., Pritchard, H.W. and Walters, C. 2018. Longevity of Preserved Germplasm: The Temperature Dependency of Aging Reactions in Glassy Matrices of Dried Fern Spores. *Plant and Cell Physiology*, 60(2): 376–392. <https://doi.org/10.1093/pcp/pcy217>
- Byrne, P.F., Volk, G.M., Gardner, C., Gore, M.A., Simon, P.W. and Smith, S. 2018. Sustaining the future of plant breeding: The critical role of the USDA-ARS National Plant Germplasm System. *Crop Science*, 58(2): 451–468. <http://www.doi.org/10.2135/cropsci2017.05.0303>
- Dafni, A. and Firmage, D. 2000. Pollen viability and longevity: practical, ecological and evolutionary implications. In *Pollen and pollination* (pp. 113–132). Springer, Vienna.
- FAO. 2011. *The state of the world’s land and water resources for food and agriculture (SOLAW) – Managing systems at risk*. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London.
- FAO. 2014. *Genebank Standards for Plant Genetic Resources for Food and Agriculture*. Rev. ed., Rome.
- Fleming, M.B., Patterson, E.L., Reeves, P.A., Richards, C.M., Gaines, T.A. and Walters, C. 2018. Exploring the fate of mRNA in aging seeds: protection, destruction, or slow decay?. *Journal of experimental botany*, 69(18): 4309–4321. <https://doi.org/10.1093/jxb/ery215>
- Franchi, G.G., Piotto, B., Nepi, M., Baskin, C.C., Baskin, J.M., and Pacini, E. 2011.

- Pollen and seed desiccation tolerance in relation to degree of developmental arrest, dispersal, and survival. *Journal of Experimental Botany*, 62: 5267-5281.
- Havens, K., Guerrant, E.O. Jr., Maunder, M., and Vitt, P. 2004. Guidelines for *ex situ* conservation collection management: Minimizing risks. Pages 454-473. In Guerrant E.O. Jr., Havens K., and Maunder M. (eds.) *Ex Situ Plant Conservation: Supporting Species Survival in the Wild*. Island Press, Covelo.
- Hay, F.R. and Probert, R.J. 2013. Advances in seed conservation of wild plant species: a review of recent research. *Conservation Physiology* 1: <https://doi.org/10.1093/conphys/cot030>
- Kendra, P.E., Montgomery, W.S., Niogret, J. and Epsky, N.D. 2013. An uncertain future for American Lauraceae: a lethal threat from redbay ambrosia beetle and laurel wilt disease (a review). *American Journal of Plant Sciences*, 4(03): 727-738. <http://dx.doi.org/10.4236/ajps.2013.43A092>
- Mazur, P., Leibo, S.P., Seidel, Jr. G.E. 2008. Cryopreservation of the germplasm of animals used in biological and medical research: importance, impact, status, and future directions. *Biology of Reproduction*, 78(1): 2-12. <https://doi.org/10.1095/biolreprod.107.064113>
- Pence, V.C. 2013 Tissue cryopreservation for plant conservation: potential and challenges. *International Journal of Plant Sciences*, 175: 40-45. <https://www.jstor.org/stable/10.1086/673301>
- Polge, C., Smith, A.U., and Parkes, A.S. 1949. *Revival of Spermatozoa after Vitrification and Dehydration at Low Temperatures*. *Nature*, 164: 666. <https://doi.org/10.1038/164666a0>
- Righetti, K., Vu, J.L., Pelletier, S., Vu, B.L., Glaab, E., Lalanne, D.... Leprince, O. 2015. Inference of longevity-related genes from a robust coexpression network of seed maturation identifies regulators linking seed storability to biotic defense-related pathways. *The Plant Cell* 27: 2692-2708. <https://doi.org/10.1105/tpc.15.00632>
- Soulé, M. 1991. Conservation: Tactics for a Constant Crisis. *Science*, 253(5021), 744-750. Retrieved from <http://www.jstor.org/stable/2879113>
- Vavilov, N.I. 1987. *Origin and Geography of cultivated Plants*. Translated to English by D. Love 1992. Cambridge Univ Press.
- Velásquez, A.C., Castroverde, C.D.M., and He, S.Y. 2018. Plant-Pathogen Warfare under Changing Climate Conditions. *Current Biology*, 28(10): R619-R634. <https://doi.org/10.1016/j.cub.2018.03.054>
- Walters, C., Ballesteros, D., and Vertucci, V.A. 2010. Structural mechanics of seed deterioration: standing the test of time. *Plant Science*, 179(6): 565-573. <https://doi.org/10.1016/j.plantsci.2010.06.016>
- Walters, C., Berjak, P., Pammenter, N., Kennedy, K., and Raven, P. 2013. Preservation of recalcitrant seeds. *Science*, 339(6122): 915-916. <http://www.doi.org/10.1126/science.1230935>
- Walters, C. 2015. Orthodoxy, recalcitrance and in-between: describing variation in seed storage characteristics using threshold responses to water loss. *Planta*, 242(2): 397-406. <https://doi.org/10.1007/s00425-015-2312-6>
- Walters, C., Richards, C.M., and Volk, G.M. 2018. Ex situ conservation of germplasm collections from natural populations (pp 209-228). In S. Green, L.F. Marek, C. Khoury (eds) *North American Crop Wild Relatives*, vol 1, conservation Strategies. Springer Cham, Switzerland.
- Worldbank. 2019. Development Indicators, updated 24 April 2019. <http://datatopics.worldbank.org/world-development-indicators/themes/environment.html> (visited site on 4 May 2019).

## THE NATIONAL COLLECTION OF COLOMBIA'S NATIVE PALMS: A TESTIMONY OF LOVE FOR PLANET EARTH

ALBERTO GÓMEZ-MEJÍA\*

### Colombian floral diversity

The nation of Colombia is a biodiversity hotspot that includes three chains of the tropical Andes and the flatlands on both sides of the mountains. It has enormous ecological and biological diversity, with about 30,000 known species of vascular plants, 6,500 of them endemic (Bernal et al., 2019). Among the reasons for this floristic richness are its geographical position and complex orography, a varied climate, and its geological history, with the Andean ranges rising to their present heights only within the past several million years.

Colombia's biodiversity and ecological stability is being eroded by its rapid rate of deforestation, with some 200,000 hectares of relatively undisturbed forest destroyed each recent year – equivalent to about one hectare of forest lost every hour (González et al., 2011)<sup>1</sup>! According to the Colombian Institute of Natural Sciences of the National University of Colombia, out of 30,000 Colombian native plant species, about 7,500 are subject to some category of threat of extinction (Bernal et al., 2019).

The main causes of deforestation in Colombia are:

- To secure land for growing illicit crops, especially coca.
- The extension of agricultural lands, owing in part to inequities in land ownership.
- Cutting and burning large quantities of wood as fuel.
- Disturbance associated with mining, both legal and illegal.
- The expansion of urban areas.

These causes have a common factor: they are all driven by economic gain. This means that the devastation and degradation of a very biodiverse

\* Founder and President of Quindío Botanical Garden. President of Colombian Botanic Gardens Network since 1996.

<sup>1</sup> See also <http://www.ideam.gov.co/documents/24277/84382637/Detecciones+Tempranas+de+Deforestaci%C3%B3n/96e81976-195e-4d0f-8aaf-24c05c7312f8> (last accessed on November 19, 2019).

country like Colombia is taking place for the sake of economic benefits. Although the current population of about 50 million people is growing at only 0.9% per year,<sup>2</sup> higher living standards mean increased consumption by all sectors of society. The main consequences of this “ecocide” are:

- Extinction of biological species.
- Degradation of natural ecosystems.
- Climate change, exemplified by the loss of most glaciers that were active 50 years ago.
- Alteration of water cycles, often leading to seasonal drought.
- Soil loss.
- Impoverishment of human communities and many other damages.

In short: a real drama.

With humans continually driving the destruction of nature with large parts of the populace still living in poverty, it is certain that future generations of Colombians will not have the biological richness and relative ecological stability that we enjoy today. Among the causes are:

- The absence of leaders with ethical behavior toward nature.
- The insufficient political awareness of the population about their environmental rights.
- A general lack of knowledge about what nature provides for everyone – the extent to which we depend upon it for our everyday lives.

The Holy Father Francis has said: “*The cost of the damage caused by such selfish lack of concern is much greater than the economic benefits to be obtained. Where certain species are destroyed or seriously harmed, the values involved are incalculable. We can be silent witnesses to terrible injustices if we think that we can obtain significant benefits by making the rest of humanity, present and future, pay the extremely high costs of environmental deterioration*”. (Encyclical letter *Laudato si'*).

The botanical gardens of Colombia (and throughout the world) form a kind of living “Noah’s Ark” for saving as much as possible of our native plant diversity. How much can we hope to accomplish before the overall destruction of nature is complete?

The answer is that Colombian people (and all those who want to help us) must work very hard to preserve as much as possible of the native Nature that we enjoy today...

The Quindío Botanical Garden, the institution that I head, is one of the gardens attempting to preserve floral diversity (Figure 16.1). It is a

<sup>2</sup> <https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/censo-nacional-de-poblacion-y-vivenda-2018/cuantos-somos>

non-governmental and a non-profit organization, founded in 1979, located in Calarca, Quindío, Colombia, only twenty minutes from the International Airport of Armenia city. Our goals include the conservation of nature, a goal that we hope to realize by spreading a love of our natural surroundings among all of our visitors and those who live in the surrounding communities (Figure 16.2). In doing so, we have adopted a concrete goal, the preservation of as many as possible of the palm species that grow within the borders of Colombia.



**Figure 16.1.** Partial view of Quindío Botanical Garden. *Source:* QBG photo.



**Figure 16.2.** Kids learning about native flora in Quindío Botanical Garden. *Source:* photo by Laura Guerrero.

## Diversity of Palms in Colombia

With 260 species, Colombia has the third highest number of palms that occur in any country and the second highest in the New World. Our native palm species amount to a tenth of the 2,600 palm species that occur globally, which indicates a very high proportion. They are distributed throughout the country, from sea level to 3,200 meters of elevation (Galeano & Bernal, 2010). Palms are important components of tropical forests in their diversity, abundance, and as critical sources of food for wildlife. Economically, they are the third most important plant family in the tropics, following the grasses and the legumes (Johnson, 1996). Among the Colombian palm species, about 80%, some 205 species, are in serious danger of extinction (Galeano & Bernal, 2010). For that reason, and because of their overall importance, the Quindío Botanical Garden decided in 1993 to build a living collection of as many species of Colombian palms as possible; our collection is now the most diverse representation of these palms globally. We bring together living plants of all palm species native to Colombia and use them as tools for education, research, and conservation. In addition, we will endeavor to reintroduce as many of our threatened species of palms as possible back into their original habitats. To accomplish these aims, we have during the past 12 years conducted 13 expeditions reaching all areas of the country, and we hope to extend this effort in the future.



**Figure 16.3.** *Sabinaria magnifica*. It occurs in Serrania del Darien, near Panama. *Source:* Photo by Hector Manrique.



The eminent Colombian Botanist Rodrigo Bernal has helped us a great deal in these efforts. Today, our collection includes 214 of the 262 species known in Colombia and all but one of the 45 native genera.

The national tree of Colombia is the Quindío wax palm, *Ceroxylon quindiuense*. It is the tallest species of palm globally, reaching 60 m in height, and it occurs up to a higher elevation than any other palm, reaching an elevation of 2,200 meters in the Andes.



**Figure 16.4.** *Ceroxylon quindiuense*. *Source:* Photo by Rodrigo Bernal.

The genus *Ceroxylon* was discovered by Alexander von Humboldt and Aimé Bonpland in the Andes (1801–1803). There are twelve species which occur in the mountains from Colombia to Bolivia; of these, seven occur in Colombia.

In addition to palms, we preserve in the Quindío Garden cycads, gymnosperms with divided leaves that resemble those of palms. The most diverse genus of cycads in Colombia is *Zamia*, with 23 of the 60 known spe-

cies occurring in our country (Calderón et al. 2005, Esquivel 2014). These occur widely, from the seashore to more than 3,000 m of elevation. As a result, our garden, which comprises 11 *Zamia* species, has earned the honor of being a member of the Colombian *Zamia* rescue group, Conservation Action Plan 2015–2025. In doing so, we assist in our national effort to save as many as possible of these attractive plants.

## Conclusion

Although modern botanical gardens were developed in Europe starting in the 1540s – originally as adjuncts to medical schools for learning and teaching about medicinal plants – they spread with European colonization to North America and throughout Asia. Thus, the Calcutta Botanical Garden was founded in 1787, with most of the other Asian gardens started by colonizers such as England and the Netherlands in the first half of the 19th century as testing grounds for plants of economic value.

In the tropics generally, where over two-thirds of the world's plant species occur, most nations did not have or form gardens until the 20th century, many of which were also initiated in a colonial context. Thus, it is relatively recently that botanical gardens in many tropical countries began to play a role in conserving the plants of their respective countries. Given the rapid rate of destruction of their floras, it is to be hoped that ways and means may be found to help in the development of botanical gardens and to promote networking between these institutions for the common good. We seem to be off to a solid start in Colombia and hope that we will be able to find means for accelerating efforts to preserve our extraordinarily rich native flora while it remains relatively intact.

## Bibliography

- Bernal, R., S.R. Gradstein & M. Celis (eds.). 2019. Catálogo de plantas y líquenes de Colombia. Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá. <http://catalogoplantasdecolombia.unal.edu.co>
- Calderón, E., Galeano G., García N. (eds). 2005. Libro Rojo de Plantas de Colombia. Volumen 2. Palmas, Frailejones y Zamias. Serie Libros rojos de especies amenazadas de Colombia. Bogotá, Colombia. Instituto Alexander von Humboldt – Instituto de Ciencias Naturales de la Universidad Nacional de Colombia – Ministerio de Ambiente, Vivienda y Desarrollo Territorial.
- Esquivel, H.E. 2014. Taxonomía, sistemática e importancia de las gimnospermas. Segunda edición. Ibagué. Universidad del Tolima.
- Galeano, G. & R. Bernal. 2010. Palmas de Colombia: Guía de Campo. Editorial Universidad Nacional de Colombia. Instituto de Ciencias Naturales, Facultad de Ciencias-Universidad Nacional de Colombia, Bogotá D.C.

- González, J.J., Etter, A.A., Sarmiento, A.H., AM. Bogotá D.C., Colombia.  
Orrego, S.A., Ramírez, C., Cabrera, E., Johnson, D. (ed). 1996. Palms: Their Conservation and Sustained Utilization – Status Survey and Conservation Action Plan. IUCN, Gland, Switzerland and Cambridge, UK.  
Vargas, D., Galindo, G., García, M.C., Ordoñez, M.F. 2011. Análisis de tendencias y patrones espaciales de deforestación en Colombia. Instituto de Hidrología, Meteorología y Estudios Ambientales-IDE-

- ▶ **V. Overarching Issues: Scientific, Moral/ Religious, and Political Aspects of Species Conservation and Human Behavior Change**



## **POLICIES IN ETHIOPIA ON PROTECTION OF NATURE AND SPECIES**

**HAILEMARIAM DESALEGN\***

### **Biodiversity in Ethiopia**

Ethiopia is characterized by great geographic diversity and displays significant macro and micro climatic variability. 60% of Ethiopian landmass is mountainous, similar to the geography of Colombia. Ethiopia is also the site of one of the lowest elevations in the world – that is, apart from the Dead Sea – so it is a mountainous place but also has the Danakil Depression as one of the lowest places on Earth. Linked to this particular geography there is great biodiversity in Ethiopia, which is one of the most important issues for our economy, ecology, and lifeline. In fact, Ethiopia is considered one of the most important biodiversity hotspots of the world, endowed with an impressive diversity of plants, animals, and microbial genetic recourses. It hosts two of the biodiversity hotspots of the world, namely: The Eastern Afromontane and The Horn of Africa Hotspots.

Politically, Ethiopia is deeply committed to keep its diverse environment safe for the purpose of human existence. Globally, Ethiopia is known for suffering from famine but this has happened not because Ethiopia did not have any resources but because we have not managed our biodiversity properly. Therefore, Ethiopia's biodiversity is an existential issue for us. It is not just a policy issue like any other policy, but an existential issue for the country.

However, our diversity is subject to direct and indirect threats. Similar to other contributions to this conference, habitat conversion is also a direct threat to biodiversity in Ethiopia and it is paired with the unsustainable utilization of resources and the pollution of the environment. Among the direct threats to biodiversity are furthermore invasive species entering Ethiopia. Climate change as a context, which affects Ethiopia through recurrent droughts and complicates the situation in Africa in general, specifically though in the Horn of Africa, also belongs to these kinds of threats, as does the replacement of local varieties and breeds.

\* Former Prime Minister of Ethiopia and Chairperson of Hailemariam & Roman Foundation.

In contrast to other continents, though, the demographic change, which is taking place in Africa, is so rapid that it has great implications for biodiversity and thus poses an indirect threat to biodiversity. Ethiopia's population doubled from about 50 million people in 1990 to about 100 million in 2015 (United Nations, 2019a) and is expected to further increase from currently about 112 million people (2019) to more than 205 million people by 2050 (United Nations, 2019b). This demographic change further exacerbates the numbers of people living in poverty and intensifies the need for land for livelihoods and sites of agrarian production. After all, Ethiopia is an agrarian society such that large parts of its population are dependent upon natural resources and the environment as their principal source of income. Finally, the poor infrastructure in large parts of the country and periods of political unrest pose additional challenges for the loss of biodiversity and management of environmental resources within Ethiopia.

### **National Policy on Biodiversity Conservation**

Biodiversity plays a key role in economic, ecological, and social fabrics in Ethiopia. Agriculture, which also includes forestry, is the dominant economic sector accounting for 83% of employment, 90% of export value, and 40% of GDP. Forests play vital roles in ensuring food security and sustainable livelihoods for millions of households throughout Ethiopia. In Ethiopia, protected areas cover 14% of the country. They play significant roles in conservation, recreation, eco-tourism, and employment. Thus, a focus in our policymaking was how to manage our protected areas in a sustainable manner. We have different types of protected areas that have been established to conserve and sustainably utilize our resources. We are very keen to see that our protected areas are really well protected because there are a number of issues that have to be addressed.

The first one is to ensure that physically these areas are protected. Yet, if we do not have an alternative livelihood for the indigenous communities in the protected areas, I think that the degradation of those protected areas is obvious. Thus, when we talk about protected areas we have to talk about indigenous communities. They have to own the protected areas and benefit from the protection and biodiversity conservation. Therefore, this is one of the policy areas we focus on.

The second issue that has to be addressed in the context of protected areas is invasive species and alien species which, as mentioned earlier, pose a threat to biodiversity. In Ethiopia, we have a number of invasive species that have come in, and our policy is also informed by these issues. The

rehabilitation and restoration of protective areas is one of the issues that we are working on as a policy information but, when we talk about this issue, conservation-oriented restoration is a very important issue we have to discuss and refine. We have some exotic species in the plantations, which have been created. Nevertheless, the forest coverage, which used to be in the 1900s about 40%, has declined to 2.7% in the 1990s. Since 1990, the Government has taken aggressive action and now our forest coverage has increased again to 18%, which is a huge achievement. Yet, if we look into the details of this restoration, indigenous species are largely lacking, as it can be seen that only 2-3% of different kinds of trees have been planted. We have to work on how to realize native-tree plantations and this needs some kind of support in Ethiopia. We need to carefully and skilfully address this issue.

The last issue is public awareness and education and so far this area is lacking. Combined ex-situ and in-situ conservation issues are also one of the areas on which we focus in policy discussion and formulation. The question of which judicial mechanisms we can employ to deal with this issue is one of the main challenges.

Based on the rationale that in Ethiopia the conservation of biodiversity is one of the conditions of overall socioeconomic development and sustainable environment management, the National Policy on Biodiversity Conservation and Research was issued in April 1998. It provides a general framework towards effective conservation, rational development and sustainable utilization of genetic resources. It comprises the following topics: sustainable management of protected areas, control of invasive species, rehabilitation and restoration of degraded areas, sustainable biodiversity management, creating public awareness, ex-situ and in-situ conservation, and access and benefit sharing.

An example of an internationally supported project whose aim is in line with the National Policy on Biodiversity Conservation and Research is called “Sustainable development of the protected area system of Ethiopia” (SPDASE). From 2008 to 2016, SPDASE was run by the Ethiopian Wildlife Conservation Authority (EWCA) as the lead executing agency to develop capacity to effectively manage the national protected area system. It thereby focused on activities that have a knock-on effect within the management of protected areas, including the demarcation of protected areas, the maintenance and procurement of equipment, as well as the training of scouts through national and international experts (UNDP Ethiopia Country Office, 2019).



## **The Ethiopian Biodiversity Conservation Institutions**

Wildlife, nature and species in Ethiopia are preserved in protected areas. When it comes to institutions, we have the Ethiopian Wildlife Conservation Authority, which manages 13 of our national parks, wildlife reserves and sanctuaries, measuring over 3.75 million hectares of natural habitat, including 1.8 million hectares of forest and woodlands. This represents almost 20% of the total remaining natural forest cover in Ethiopia. Consequently, this is one of the key initiatives to address the issue of biodiversity conservation, and our policies also support the establishment of this institution. The Ethiopian Institute of Biodiversity Conservation (IBC), the Ethiopian Wildlife and Natural History Society, regional park authorities, and botanical and zoological gardens, which are mainly located in Addis Ababa City as well as in regional cities and universities, play an important role in this context.

However, there is one specific story about Ethiopia, which is the millennium parks administration. At the time of the Ethiopian millennium – which took place eight years after that of the Gregorian calendar – the public had discussed issues of existential threat for Ethiopia and its population because of biodiversity loss. That was the main agenda in our millennium such that we said we have to achieve our survival in biodiversity. We have to go back to our own initial existence. We recognized that we had destroyed it in the past millennia and that we have to restore it in this third millennium. This was the message that the entire Ethiopian population discussed, and every village in the country established a millennium park, which is managed by the community in each village. The villages own these parks and in their management focus on indigenous trees. This is one of the movements that was launched during our millennium.

In Ethiopia we have national parks and we have controlled hunting areas. Furthermore, we have sanctuaries and wildlife reserves. Together, these areas cover 20% of the landmass of the country. Along the Great African Rift Valley is a very fragile ecosystem, for which reason we have to focus on this area in Ethiopia. This is where we have our natural resources that should be preserved. In this natural setting, some of the plants are unique to Ethiopia. In the highest part of the country, there are also tourist attractions but any ecotourism must be friendly to biodiversity.

## **Environmental Policy of Ethiopia**

In addition to the biodiversity conservation policy, we have related policies and strategies. The Government of Ethiopia has included environmental issues in federal and regional constitutions and has passed new policies

and legislation. In 1995, we had discussions to revise our Constitution. A focus of our agenda was the environmental and biodiversity issue. After rigorous discussions, the Ethiopian people decided that the Constitution should include claims regarding the environment and biodiversity such that any political party coming into power is obliged to act according to constitutional provision. This is one important step that has been taken in Ethiopia.

The second step is the Environmental Policy of Ethiopia, which characterizes natural resources as playing a pivotal role for the country's economy. By setting specific guiding policy directions, it fosters the development of sector-specific strategies like the Forest Sector Strategy, which is one of the strategies that underpins biodiversity conservation policy, in addition to cross-sectoral strategies like the Climate-Resilient Green Economy Strategy. The Environmental Policy of Ethiopia attributes the prevalence of poverty in part to low growth and low productivity in the agricultural sector and in part to the populace's dependence on agriculture and natural resources. The general objective of the policy thus is to improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment as a whole, so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. Within this framework, the Environmental Policy of Ethiopia has been legislated and that is the basis of our work for now.

### **Ethiopia's Climate-Resilient Green Economy Strategy**

Apart from that, Ethiopia has designed its own Climate-Resilient Green Economy Strategy, which is indeed unique. We wanted to show the global community that, even though our contribution to the worldwide greenhouse gas emission is minimal, as responsible global citizens, we are going to focus on our green economy development and we established this strategy. Ethiopia is acting as an advocate representing Africa's claim for climate justice. As Africans, we are fighting with one voice for the global climate change issue as the international community, especially the United States, is stepping back from the Paris Agreement. Africa is the continent most affected by climate change, which we did not cause by our actions. Therefore, the international community has to understand and support us in such a way that Africa is not extinguished from this world. It is our role as responsible citizens to function as advocates for climate justice, yet it is the obligation of the others to respond to our claims. We are highlighting

the moral responsibility of the wealthy countries: If even we as poor countries are doing this, then they have to be morally responsible to save this globe. This way, we are speaking with one voice as Africans to engage with the global community in climate-resilient green economy strategy design and the reduction of greenhouse gas emission to the necessary agreement we committed to in Paris.

Clearly, it is the objective of our Climate-Resilient Green Economy Strategy to identify green economy opportunities that could help Ethiopia reach its ambitious growth targets (which are stipulated in the Growth and Transformation Plan) while keeping greenhouse gas emissions low. We are focusing on climate-smart agriculture and livestock production as well as on climate-smart forestry, clean and green energy mainly from renewable sources and also green buildings, industries, and transportation. These are the four pillars of our economic strategies. An example of how we reduce greenhouse gas emission is a city light-rail transit, which is electrically driven and which is complemented by many similar projects throughout Ethiopia.

### **Forest Sector Strategy**

Ethiopia's diverse forest resources, including high forests, woodlands, and trees on farms, provide goods and services of important value to Ethiopia's people, environment, and economy. Neo-Timber Forest Products (NTFPs) play an important role in rural livelihoods and the growing market-based economy. The main commercial NTFPs in Ethiopia are honey, spices, forest coffee, mambo, gums, and resins. Ethiopia's forests are also important for climate stabilization, contributing to global climate mitigation goals and providing local climate adaptation benefits. However, as explained earlier, our forest coverage was 40% in 1900 but then declined until 1990 and was 15% in 2015, and has further increased in 2019.

This is particularly relevant as there is a growing demand for wood, which increasingly puts a burden on the forest. In 2017, Ethiopia consumed roughly 124 million cubic meters of wood, and the level of consumption is on the rise. In fact, the growth of demand is expected to increase by 27% over the next 20 years, thus reaching an annual consumption of 158 million cubic meters by 2033. Wood fuel (fuel wood and charcoal) will continue to be the main forest product consumed. Today, Ethiopia consumes over 100 million cubic meters of wood fuel each year, with roughly one third of this amount coming from unsustainable use of forests and woodlands. Thus, a comprehensive sustainable means of forest

management needs to be in place. In light of the Climate-Resilient Green Economy Strategy, the Ethiopian Forest Strategy must thus comprise the reduction of emissions from deforestation and forest degradation while focusing on forest conservation and sustainable forest management. Forest carbon stock enhancement can be achieved through both afforestation and reforestation, which furthermore give special attention to the planting of indigenous trees.

### **Environmental, Climate Change, and Forestry Policy Administration**

The Environmental Forest and Climate Change Commission (EFCCC) is the primary agency at the federal level responsible for managing environmental issues. The particular responsibilities of the EFCCC include the following areas: development of environmental legislation and policy, setting of standards, monitoring of environmental policies, implementing environmental impact assessments (EIAs) for proposed development activities, negotiating access and benefit sharing agreements, and undertaking capacity development in relevant agencies to ensure the integration of environmental management into policymaking. These responsibilities are associated with explicit objectives of the EFCCC, such as enabling the fast economic growth of the country to be sustainable and in so doing guarantee environmental safety. Furthermore, the EFCCC ensures that the Climate-Resilient Green Economy Strategy is implemented in all sectors. This objective is linked to Ethiopia's desire to become a middle-income country by 2025. Finally, the EFCCC aims at improving forest development, protection and utilization to increase the economic, social, and ecological benefit to be obtained from forest resources.

Most large-scale environmental administration is dispersed between the federal government and administrative subdivisions, including nine regional states and two chartered cities. Therefore, on the regional level, states have similar institutions in place to manage policies related to environment, climate change, and forestry.

### **Conclusion**

Even though Ethiopia has still been able to conserve some of the most important biodiversity in nature and species, these resources are at risk of immediate extinction unless integrated wide-range actions are taken by policy makers and implementers. Even though there is political commitment, the implementation is starkly lagging behind, which calls for instant and concentrated efforts.

The policy programs and actions recognize the immediate need and are acting in concerted effort to alleviate biodiversity degradation. However, increase in population and high dependence on natural resources pose a great challenge to effectively implementing the policies on the ground. Due emphasis should be given to various governmental and societal levels in order to enable them to understand these challenges and act wisely to benefit the current generations, without compromising the benefits at present and in the future.

### **Bibliography**

- UNDP Ethiopia Country Office (UNDP) (2013). Sustainable Development of the Protected Area System. Last accessed on September 19, 2019, at <https://www.et.undp.org/content/dam/ethiopia/docs/UNDP%20Ethiopia%20Fast%20Facts%20-%20Sustainable%20Development%20of%20Protected%20Areas%202013.pdf>
- United Nations, DESA, Population Division (2019a). World Population Prospects 2019. Last accessed on September 19, 2019, at <http://population.un.org/wpp/>
- United Nations, DESA (2019b). World Population Prospects 2019: Data Booklet. Last accessed on September 19, 2019, at [https://population.un.org/wpp/Publications/Files/WPP2019\\_DataBooklet.pdf](https://population.un.org/wpp/Publications/Files/WPP2019_DataBooklet.pdf)

# ENGAGING TRADITIONAL POPULATIONS AND INDIGENOUS PEOPLES IN BIODIVERSITY CONSERVATION THROUGH AMAZON BIOECONOMY

VIRGÍLIO VIANA\*

## Introduction

The Amazon is fundamental to the future of the planet because of its role for biological conservation and the global climate. The Amazon houses the highest levels of biodiversity of several taxonomic groups in the world. The region is under a high level of threats to biodiversity due to human activities. After a period (2003–2013) during which deforestation rates were reduced from 27,000 to 4,000 square kilometers per year, rates of forest loss are now rising. Deforestation rates in 2018 reached almost 8,000 square kilometers per year.

Globally, biodiversity loss is at record level, with over 1 million species threatened by extinction (IPBES 2019). The Amazon holds 58.8% of the biome in Brazil, and this proportion varies among different countries (Table 18.1). Deforestation can push the biome past a tipping point, which may bring about a collapse of the hydrologic cycle and ecosystem dynamics and, ultimately, lead to species loss (Lovejoy and Nobre 2018).

The big question is how to keep the forest standing, thus reducing deforestation and securing the production of environmental services on which our common future depends. The most promising solution is to make forests worth more standing than cut. This concept, formulated as part of a set of state public policies in the Amazonas State in 2003, has received increasing support from those who seek ways to prevent the continued deforestation of the Amazon and an ecological collapse or tipping point. Increasing the value of standing forests has to be based on a strategy to promote the Amazon Bioeconomy.

\* General Director of the Sustainable Amazon Foundation (FAS), Ph.D. (Harvard University), Former Secretary of State of Amazonas for Environment and Sustainable Development (2003–2008).

**Table 18.1.** Total area, biome, and forest loss per Amazon country.

COUNTRY	TOTAL AREA (million square km)	% OF TOTAL AMAZON BASIN FOUND IN EACH COUNTRY	% OF AMAZON BASIN FOR EACH COUNTRY	% OF TOTAL AMAZON BIOME FOUND IN EACH COUNTRY	% OF AMAZON BIOME FOR EACH COUNTRY	% FOR- EST LOSS
Brazil	8,516,000	71.5	66	64.3	58.8	17.6
Bolivia	1,099,000	9.2	66	6.1	43.2	7.3
Colombia	1,142,000	4.4	30	6.2	42.3	9.9
Ecuador	283,560	1.8	51	1.5	41.1	10.7
Guiana	214,970	0.1	5	2.8	100.0	2.5
French G.	83,534	0	0	1.1	100.0	2.8
Peru	1,285,000	12.3	75	10.1	60.9	9.1
Suriname	163,821	0	0	2.1	100.0	4.2
Venezuela	916,445	0.7	6	5.8	49.5	3.3
Total	13,704,330	100		100		6.2

Source: SDSN-Amazonia at <https://www.sdsn-amazonia.org/pt-plataforma>.

A strategy to promote Amazon Bioeconomy has to engage local communities in the design and implementation of innovations. Participatory approaches can create bridges between traditional knowledge and conventional science and technology. The Sustainable Amazon Foundation (FAS) has valuable experience in translating this into practice (Viana 2010, Viana 2019).

This paper will focus on how to engage Amazon traditional populations and indigenous peoples in biodiversity conservation through bioeconomy. First, it will present some of the results of FAS regarding practical action to prevent biodiversity loss. Then, it will draw on the experience of FAS to propose a framework to support Amazon bioeconomy.

### Results from practical action of FAS

The Sustainable Amazon Foundation (FAS) works with 581 communities of traditional riverine populations in an area of 11 million hectares. In addition, FAS supports grassroots organizations that defend the rights of indigenous peoples and poor urban populations in the Amazon. FAS works in partnership with the Government of the State of Amazonas to implement the *Bolsa Floresta* Program, a public policy to compensate forest dwellers that commit for zero deforestation of primary forest and practices to prevent forest fires.

The approach used by FAS is based on an innovative social technology, which is widely recognized both nationally<sup>1</sup> and internationally.<sup>2</sup> FAS social technology relies on a number of participatory methods for designing and implementing solutions for local sustainable development. These solutions encompass all 17 Sustainable Development Goals, ranging from breast-feeding and early childhood development to income generation based on sustainable management of natural resources.<sup>3</sup>

Deforestation rates have been reduced in the 16 protected areas that benefit from the social technology and investments of FAS, directly and indirectly associated with the Bolsa Floresta Program (Figure 18.1). Deforestation rates were reduced by 30% and 43% for two consecutive 5-year periods, 2008–2012 and 2013–2017, respectively.

Deforestation rates in protected areas with FAS activities had a reduction of 17% in the 2015–2017 period (Figure 18.2). In the same period, deforestation in other state-protected areas (without FAS activities) increased



**Figure 18.1.** Total deforestation rate in 16 protected areas with FAS activity, based on satellite imagery. *Source:* INPE/PRODES – www.obt.inpe.br

<sup>1</sup> <http://www.ogirassol.com.br/viver/fas-e-eleita-a-melhor-ong-da-regiao-norte-pela-revista-epoca>

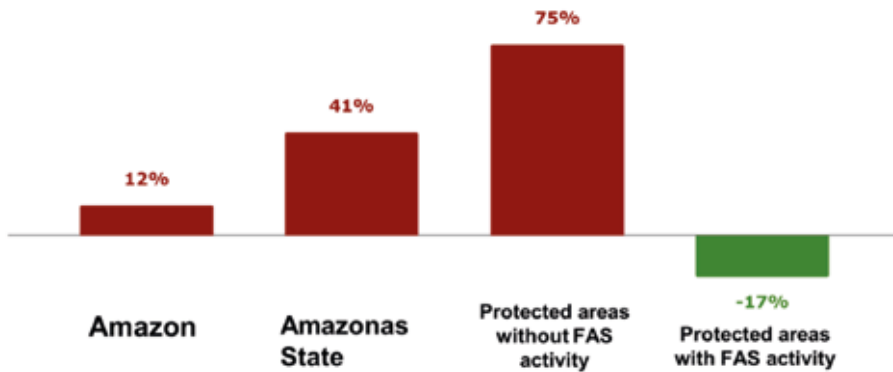
<sup>2</sup> <https://gulbenkian.pt/en/news-en/2016-calouste-gulbenkian-prize/>

<sup>3</sup> <http://fas-amazonas.org/?lang=en>

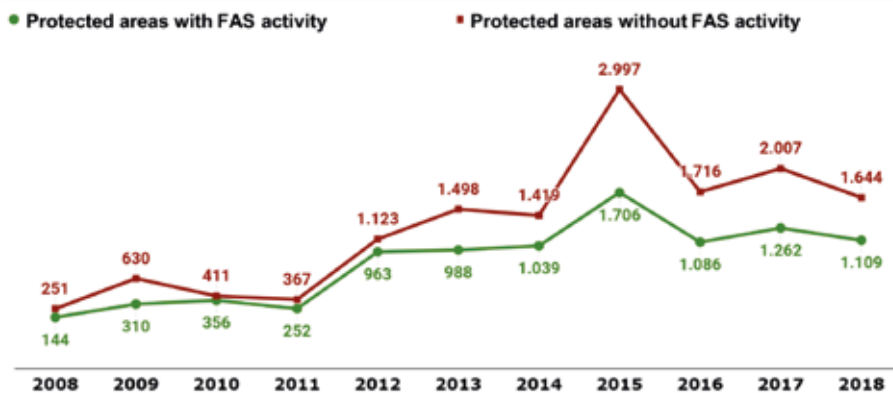


by 75% and was thus much higher than the average deforestation rate in the Brazilian Amazon (12%) and Amazonas State (41%).

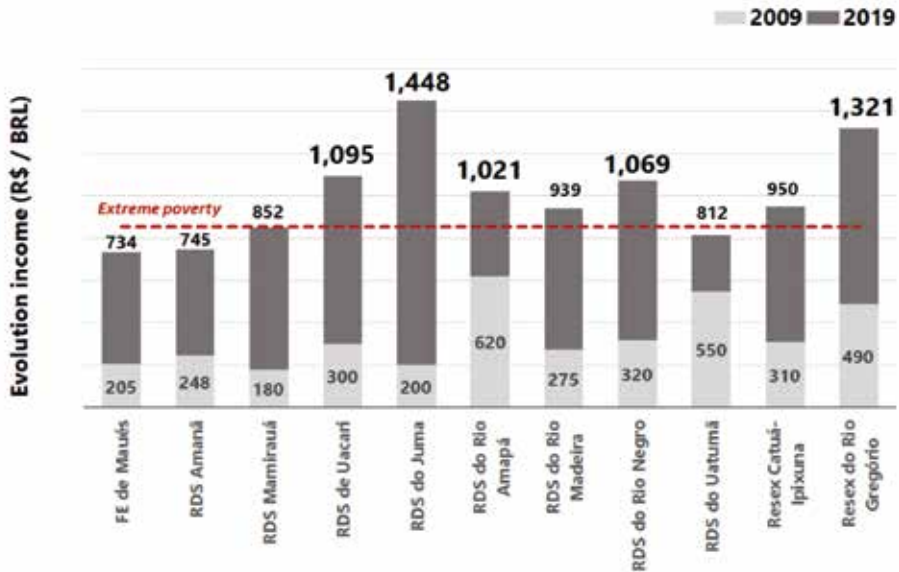
Forest fires are increasing in the Amazon and this is one of the greatest threats to biodiversity conservation and climate change (Figure 18.3). The fires are possibly associated with climate-driven changes in precipitation patterns (Butt et al. 2011; Marengo et al. 2018). Protected areas with FAS activities, however, have had consistently less forest fires than other state-protected areas.



**Figure 18.2.** Deforestation rates comparison (2015 to 2017) in 16 protected areas with FAS activities compared to other state-protected areas without FAS activities, to the Brazilian Amazon and to Amazonas State. *Source:* INPE/PRODES – [www.obt.inpe.br](http://www.obt.inpe.br)



**Figure 18.3.** Forest fires in 16 protected areas with FAS activity, compared to other state-protected areas without FAS activities. *Source:* INPE/PRODES – [www.obt.inpe.br](http://www.obt.inpe.br)



**Figure 18.4.** Evolution of income in 16 protected areas with FAS activity. *Source:* FAS unpublished article.

Monetary income in areas with FAS activity has increased by 124% in the 2009–2016 period (Figure 18.4). All areas had prohibitive increases in monetary income, which varied from 16% to 284%. Four of the eleven areas analyzed had an average income higher than the extreme poverty level. Subsistence economy is, however, not included in this analysis. Therefore, these figures underestimate the total income.

FAS activities are structured around the concept of *making forest worth more standing than cut*. These activities include (i) formal education, (ii) technical, graduate education and, (iii) support to entrepreneurship, (iv) development of multi-institutional alliances, and (v) contributions to public policies. The results of these activities are presented in detail elsewhere.<sup>4</sup>

### **Biodiversity conservation through Amazon Bioeconomy**

Amazon Bioeconomy can be defined as *all economic activities related to productive chains based on the management and cultivation of native Amazon biodiversity, with value added locally, while generating positive impacts for local*

<sup>4</sup> <http://fas-amazonas.org/?lang=en>

*and regional sustainable development.* The Amazon Bioeconomy includes the production chains of bio-cosmetics, biopharmaceuticals, nutraceuticals, biopigments and other products derived from native biodiversity of the Amazon and associated ethnoecological knowledge.

There is a large number of research institutions, civil society organizations, government agencies, and companies investing in programs and projects focused on Amazon Bioeconomy – including FAS. This wealth of practical experiences allows us to propose the pillars of a strategy for the promotion of the Amazon Bioeconomy based on a holistic approach. Ten strategic pillars are proposed:

1. *Education and investment in local human capital* related to knowledge on management and sustainable use of the native biodiversity of the Amazon. From primary, secondary and post-secondary school education up to the post-graduate level. From primary production to the commercialization of products, including logistics and industrial and artisanal processing of products.
2. *Science, technology, and innovation development* associated with native Amazon biodiversity. From taxonomies to clinical trials, including ecology and chemistry – among others. Demand-driven research to solve bottlenecks of production chains as well as promotion of disruptive innovation.
3. *Improvements of current production systems* associated with the native biodiversity of the Amazon. Identification of bottlenecks and solutions. Supporting knowledge exchange networks.
4. *Mapping and valuing the ethnobiological knowledge* associated with native Amazon biodiversity. Valuing knowledge and reducing the process of cultural erosion. Improvement of benefit-sharing mechanisms linked to the use of traditional knowledge of indigenous peoples.
5. *Promotion of entrepreneurship* in all stages of productive chains associated with the native biodiversity of the Amazon. Supporting entrepreneurs: from forests to industry; from micro and small businesses to large investors. From traditional products to startups based on disruptive innovations.
6. *Attracting private investment* to Amazon Bioeconomy productive chains. From primary production to commercialization of products, including logistics and industrial and artisanal processing of products. From social impact investment to conventional investment.
7. *Development of innovative arrangements for hybrid financing mechanisms* (blended finance), combining non-reimbursable resources (grants and public investment) with loans and private investment.

8. *Structural investments to promote sustainable development*, to improve livelihoods of Amazon populations and overcome structural bottlenecks that increase production costs, limit product quality and access to markets. Basic investments in access to drinking water, electricity, logistics, communication, education and health – among others.
9. *Improvement of public policies* in support of the Amazon Bioeconomy sustainable production chains. From reducing bureaucracy of legal licensing processes to proving economic incentives, including reduction of taxes for Amazon Bioeconomy. Develop new policies to compensate Amazon populations for the ecosystem services provided.
10. *Improvement of governance mechanisms* of national, state and municipal programs to support development of Amazon Bioeconomy.

Two concrete examples point the way forward to Amazon Bioeconomy. The management of pirarucu (the world's largest freshwater fish) was the subject of a technological development that allowed a recovery of the fish stocks associated with a growing and ecologically sustainable production. Investments in the production chain have resulted in large income increases for fishermen from marginalized populations living in remote areas at the heart of the Amazon. The technological development in the management and cultivation of açaí, associated with the investment in the processing industry, has given rise to a productive chain that already reaches 1.5 Billion per year, with a growing national and international market. There are other examples that deserve a greater space than the one available in this article.

It is worth remembering that the Amazon biodiversity includes over 2,500 fish species, 40,000 plants species, 70,000 insect species and 69,000 fungi species, among other forms of life. These numbers are underestimated, as researches are still far from reaching the appropriate sampling level to record all species living in the Amazon ecosystems.

Why don't we have tens or hundreds or thousands of Amazon species following the path of açaí and pirarucu? The answer is simple: Brazil has not yet developed a plan to invest seriously in the Amazon Bioeconomy. There are many specific initiatives of large or small scale, of great or no success, which have produced relevant results. We are not faced with a desert of ideas and projects. On the contrary.

### **A way forward**

In order to move the Amazon Bioeconomy agenda forward, it is necessary that ongoing initiatives are scaled up and cease to be isolated, only ad-

addressing the interests of individual groups or institutions. A broad alliance is needed in favor of the Amazon Bioeconomy.

It is in this context that the Alliance for the Bioeconomy of the Amazon (ABio) emerged in 2018. It is an alliance that involves 12 institutions, including universities, civil society organizations, and state government agencies, with the purpose of promoting collaborative actions in favor of the Amazon Bioeconomy.<sup>5</sup> The objective is to develop collaborative programs to catalyze the production chains of bio-cosmetics, biopharmaceuticals, nutraceuticals, biopigments and others. The strategy is to develop technological innovations, train human capital, foster entrepreneurship, attract private investment, and improve public policies in support of the Amazon Bioeconomy sustainable production chains.

Brazil was able to invest tens of billions of dollars so that the Brazilian Agricultural Research Corporation (EMBRAPA) and public universities could develop technologies that radically increased Brazilian agricultural productivity, which grew more than 120% from 1975 to 2017. Soybean production grew 550%, with an increase of planted area of 160% in the 1975-2015 period. Similar – or greater – gains in productivity could be achieved for the Amazon Bioeconomy.

This task requires strategic planning, with a long-term vision and with strong support from society. This should be translated into long-term and not short-term policies. These policies need to be protected from changes in government that occur every four years.

A new partnership was established in May 2019 to prepare a Strategic Bioeconomy Plan for the Amazon. This initiative involves three civil society institutions and two governing agencies.<sup>6</sup> The goal is to create, by the end of 2019, a Strategic Plan for the period 2020-2030.

The elaboration process of the Strategic Plan for Bioeconomy will involve the contracting of studies on the main productive chains of bio-cosmetics, biopharmaceuticals, biopigments, and nutraceuticals. These studies will be the object of seminars and public debates with the objective of constructing a convergent vision of the different segments of society. At the end of this process, proposals for structuring programs and projects with a

<sup>5</sup> Amazon Bioeconomics Alliance (ABIO, Portuguese acronym) <https://abioamazonia.org>

<sup>6</sup> Amazon Bioeconomics Alliance, ABIO; Secretary of State for the Environment, SEMA; Secretary of Planning, Development, Science, Technology and Innovation, SEPLANCTI; Manaus Economic, Sustainable and Strategic Development Council, CODESE and Sustainable Amazon Foundation, FAS.

long-term vision should emerge. Based on this, new partnerships will be sought to enable the necessary investments.

The Amazon Bioeconomy can offer a bridge to a future of the Amazon that can reconcile the improvement of the quality of life of the local population with the maintenance of the essential environmental services for the future of Brazil and the planet. It is a challenging task around which Amazon institutions must unite and work in a collaborative and integrated manner. In addition, it is important to expand partnerships with institutions in other regions of Brazil and other countries. This is an essential matter for our future.

The challenge is gigantic, but it must be faced with a boldness compatible with the magnitude of the importance of the Amazon to Brazil and to the world. In other words, it is a challenge that has to be faced with broad thinking, both in the time horizon and in the magnitude of financial resources.

## Bibliography

- Baccini, A., Walker, W., Carvalho, L., Farina, M., Sulla-Menashe, D., Houghton, R.A. (2017). Tropical forests are a net carbon source based on aboveground measurements of gain and loss. *Science*, 358(6360), 230–234. <https://doi.org/10.1126/science.aam5962>
- Butt, N., Alfonso de Oliveira, P., Heil Costa, M. (2011). Evidence that deforestation affects the onset of the rainy season in Rondonia, Brazil. *Journal of Geophysical Research*, 116(D11120). <https://doi.org/10.1029/2010JD015174>
- INPE (2019). PRODES – Amazônia: Monitoramento do Desmatamento da Floresta Amazônica Brasileira por Satélite. Last accessed on September 24, 2019, at <http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>
- Lovejoy, T.E., Nobre, C. (2018). Amazon Tipping Point. *Science Advances*, 4(2), eaat2340. <https://doi.org/10.1126/sciadv.aat2340>
- Marengo, J.A., Souza Jr., C.M., Thonicke, K., Burton, C., Halladay, K., Betts, R.A., Alves, L.M., Soares, W.R. (2018). Changes in Climate and Land Use Over the Amazon Region: Current and Future Variability and Trends. *Frontiers Earth Science*, 6(228). <https://doi.org/10.3389/feart.2018.00228>
- Viana, V.M. (2010). Sustainable Development in Practice: Lessons Learned from Amazonas. 3. ed. 2010. London, UK. International Institute for Environment and Development – IIED. Last accessed on September 24, 2019, at <https://pubs.iied.org/pdfs/17508IIED.pdf>
- Viana, V.M. (2020, forthcoming). Health, air pollution and forest fires in the Amazon. In Al-Delaimy, W., Ramanathan, W., Sánchez Sorondo, M. (eds.), *Health of People, Health of Planet and Our Responsibility: Climate Change, Air Pollution and Health*. Springer.
- WWF (2016). Living Planet Report 2016: Risk and resilience in a new era. WWF International: Gland. Last accessed on September 24, 2019, at [https://www.wwf.org.uk/sites/default/files/2016-10/LPR\\_2016\\_full%20report\\_spread%20low%20res.pdf](https://www.wwf.org.uk/sites/default/files/2016-10/LPR_2016_full%20report_spread%20low%20res.pdf)

## **CONSERVING THE DIVERSITY OF LIFE: A MORAL DUTY AND IMPERATIVE FOR EQUITABLE DEVELOPMENT**

MARCO LAMBERTINI\*

### **Introduction**

We are living in an age of unprecedented planetary change. There is no doubt that we are destroying our planet faster than ever, with catastrophic consequences for all life on Earth on the horizon. This is not “doom and gloom” – the risks are evident and science has never been clearer about the consequences of our impact. The astonishing decline in wildlife populations – a 60% fall in just over 40 years (WWF 2018) – is a grim reminder and perhaps the ultimate indicator of the pressure we exert on our planet. If we continue to produce, consume and power our lives the way we do now, forests, oceans and weather systems will be overwhelmed and collapse. This would have a devastating impact not just on the beautiful diversity of life we share the planet with, but for people as well, as nature is vital to sustain human society and prosperity.

The continued, unabated, rapid decline of nature and biodiversity will have tremendous economic and social costs. It jeopardizes modern civilization as we know it, and indeed could threaten our very survival. Vulnerable, often impoverished, indigenous communities, who depend more directly on natural resources and are less able to adapt to ecological degradation and climate change, will suffer first and the hardest. We already have the evidence of how environmental degradation affects the poor.

### **Species, the units of Nature and foundation of ecosystems**

When we look at nature we often watch, but fail to see. In our modern, urbanized, increasingly virtual lifestyles, we have lost the intimate connection with and understanding of the natural world that was central and essential to our lives for the vast majority of the history of the human species. So when we look at the forest we often miss the ‘forest for the trees’. That

\* Director General of WWF International.

beautiful, inspiring ‘mass of green’ is in fact a very complex web of life. It is the aggregation and interaction of thousands of species and millions of organisms that make the forest live and function.

Species are the units of natural systems, the bricks in the wall of life, and more generally biodiversity is the foundation of the functioning of ecosystems. Take species away or drastically reduce their populations, and the wall will become unsustainable and collapse, and with it the vital services that ecosystems provide, which underpin all life on Earth.

#### Wildlife under unprecedented pressure

The latest edition of the Living Planet Report (LPR) (WWF 2018) paints an alarming picture of the state of the planet: Global wildlife populations of mammals, birds, fish, reptiles and amphibians, have declined, on average, by 60% in little over 40 years, largely due to threats and pressures linked to human activity. Freshwater habitats are hit the worst, with populations having collapsed by 83%. The decline of species’ populations is especially pronounced in the tropics, with South and Central America suffering the most dramatic decline at 89% compared to 1970. In the past 30 to 50 years, we have lost 20% of the Amazon, almost half of the world’s coral reefs, and 30 to 50% of the world’s mangroves (WWF 2018).

The recently published Report of the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES 2019) paints a stark picture of nature in crisis, with 1 million species at risk of extinction, on the scale of a 6<sup>th</sup> mass extinction but this time not due to asteroids or glaciations. It is because of us. One single dominant species.

Estimates indicate that each year poachers slaughter close to 20,000 elephants, mostly for their tusks (University of Vermont 2016). In Sudan, the last male northern white rhino died last year, condemning the species to extinction despite two living females remaining. These rhinos were roaming in their thousands just a few decades ago (BBC News, 2018). Today, 90% of the world’s seabirds are estimated to have fragments of plastic in their stomach (Wilcox et al. 2015).

To summarise the deep alteration of the biosphere caused by human activities, today between 95 and 99% of the biomass of land mammals is made of humans and our domesticated animals (primarily cattle and pigs) versus only 1 to 5% of all other wild mammals. The global population of tigers in the wild is below 4,000, less than a third of the seats at Wimbledon’s center court (WWF, n.d.).



## Loss of natural spaces

Forests are disappearing at a staggering rate – “18.7 million acres of forests are lost annually, equivalent to 27 soccer fields every minute” (WWF 2019a). “Researchers estimate that each year an area of rainforest larger than the state of New York is destroyed to create grazing land” (WWF 2019b) for the production of beef. These figures are even more disheartening when you consider that eight out of ten land-dwelling species and nearly 300 million people live in forests (WWF 2019c).

We have already lost half of the world’s coral reefs and 30-50% of mangroves, inspiring and vital marine coastal habitats home to an amazing diversity of species. It has been calculated that 95% of commercially important fish species depend on these habitats in their life cycle (Lellis-Dibble et al. 2008). The Marine Living Planet Index recorded a 36% overall decline in the abundance of marine life between 1970 and 2012 (WWF 2016), while overfishing threatens about 33% of global fish stocks (FAO 2019). Hundreds of millions of people, often impoverished coastal communities, depend directly on coastal fisheries.

A recent report by the UN Food and Agricultural Organisation (FAO 2019) has highlighted how the loss of biodiversity both under and above soil can threaten the productivity and resilience of our agriculture.

Indeed, current analysis from WWF (2018) suggests that humans have already pushed four planetary boundaries beyond the limit of a safe operating space; these are climate change, biosphere integrity, biogeochemical flows (nitrogen and phosphorus), and land-system change.

The figures go on and on. And the top threats to species identified link directly to human activities, including habitat loss and degradation and the excessive use of wildlife such as overfishing and overhunting (WWF 2018). Over the past 50 years, our Ecological Footprint – a measure of our consumption of natural resources – has increased by about 190% (Global Footprint Network 2019). This is due to our production and consumption being wasteful and unsustainable, ignoring the externalities.

Our extraordinary ingenuity is brilliant in solving single problems, but not so good at predicting the consequences of our behaviours and technologies. Our obsession for growth and the way we measure economic development, fixated on goods and assets but not on the natural capital that underpins them, are out of sync with the finite nature of our planet and its resources.

## **Climate change and nature loss, two sides of today's ecological crisis**

Meanwhile, climate change remains an enormous challenge. In October last year, a landmark report warned that the world has at most 12 years to prevent climate catastrophe (IPCC 2018). Never before has the threat of irreversible damage been so close or so clear.

Climate change and the loss of nature are the two sides of today's ecological crisis. It is critical to urgently address both. Whereas climate change is exacerbating biodiversity loss, the causality goes both ways: nature plays a crucial role in trying to keep climate change in check. Many affected ecosystems – such as oceans and forests – are vital for absorbing carbon emissions. In fact, nature-based solutions will have a key role to play in achieving climate change targets. One recent study found that, worldwide, natural climate solutions could reduce emissions by 11.3 billion tonnes per year by 2030, and thus deliver 37% of cost-effective CO<sub>2</sub> mitigation by 2030 (Bas 2018).

The science is clear: unsustainable human activity is pushing the planet's natural systems, which support life on Earth, to the brink.

## **The great acceleration**

The rapid planetary change caused by human activities, driven by our ever-increasing consumption and the resulting increased demand for energy, land and water, has led many scientists to conclude that we are entering a new geological epoch: the Anthropocene. It is the first time in Earth's history that a single species – *Homo sapiens* – has had such a powerful impact on the planet.

While these changes, often referred to as the 'Great Acceleration', have brought many benefits to human society, we now understand that there are multiple connections between the overall rise in our health, wealth, food and security, the unequal distribution of these benefits, and the declining state of the Earth's natural systems. Nature, underpinned by biodiversity, provides a wealth of services, which form the building blocks of modern society; but both nature and biodiversity are decreasing at an alarming rate. It is increasingly clear that human development and wellbeing are reliant on healthy natural systems, and we cannot continue to enjoy the former without the latter.

Nature is the lifeline for the 7.6 billion people inhabiting planet Earth, providing the food we eat, the water we drink and the air we breathe. All economic activity ultimately depends on the services provided by healthy ecosystems, making nature an immensely valuable component of a nation's

wealth. It is estimated that, globally, nature provides services worth around US\$125 trillion a year.

We too often forget that we depend on nature more than nature depends on us. Economy is a subset of ecology, not the reverse.

### **The risks of nature loss**

Nature is the bedrock for the production of the most common goods and much of our way of life (products from coffee to cotton to cocoa, but also major food crops, rely on balanced and biodiverse environments). Oceans and coral reefs provide food and livelihoods to hundreds of millions of people. Forests clean the air, regulate the local climate, and retain water for rivers. Healthy soils are essential to grow crops. Mountains and glaciers are key sources of water for major rivers. Increasingly, the fragility of ecosystems poses huge risks to societal and economic stability. Quite simply, nature is the foundation for a healthy society, equitable economy for all, and global security.

In its latest Global Risks Report, the World Economic Forum (WEF, 2019) once again identified environmental risks as the biggest challenges currently facing humanity, with extreme weather and climate inaction of greatest concern to businesses and governments. This is hardly surprising when in the past year alone we have seen deadly heatwaves across Japan, ruinous hurricanes in the US, record droughts in South Africa, devastating floods in Mozambique (described as the worst ever weather-related disaster to hit the Southern hemisphere) caused by the first back-to-back typhoons ever recorded in the country, and forest fires in the Arctic.

Governments, businesses, and the finance sector are beginning to question how global environmental risks – such as increasing pressure on agricultural land, soil degradation, water stress, and extreme weather events – will affect the macroeconomic performance of countries, sectors, and financial markets.

Nevertheless, the political will to tackle these challenges head on is still not sufficiently pervasive. And time is running out.

### **The road to 2020: a unique window of opportunity**

Against the backdrop of this urgency, there is also opportunity. 2020 is a special year for the environment: the UN Convention on Biological Diversity must define its post 2020 global biodiversity framework, and the Paris Agreement has the opportunity to raise the ambition of its Nationally Determined Contributions on climate change. There will also be a first review of progress on the UN Sustainable Development Goals (SDGs) environ-

mental targets, and there is an opportunity to develop new treaties to tackle plastic pollution and protect the High Seas. These efforts can and must be supported and complemented by highly ambitious agreements and commitments from all key players: states, sub-national authorities, businesses, the financial sector, development banks, and citizens. Together, the different commitments and actions must reverse the decline in nature by 2030 for the benefit of nature and people. And while momentum globally is building, we know that this will be a sprint towards a rapidly approaching 2020.

2019 is a milestone year for the SDGs. It is the first comprehensive review of progress on all 17 goals since implementation began in 2016. This review will be held under the auspices of the 74<sup>th</sup> Session of the UN General Assembly (UNGA 74) in September 2019.

The UNGA 74 session also marks a significant shift to increase the coherence between international action on climate change, universal health coverage, sustainable development, financing for development, and Small Island Developing States' development.

The recent reports by both the IPCC (2018) and the WWF (2018) have highlighted the alarming trajectories of global warming and declining wildlife populations and in doing so, demonstrated that climate, nature, and sustainable development issues are closely interlinked and cannot be addressed with a silo mentality.

Most urgently, this year is a critical window of opportunity for clear and coherent action by Member States on the new targets of the UN Convention on Biological Diversity (CBD), which will mature in 2020. Yet current global assessments show that it is unlikely we will be able to meet nine of the twelve biodiversity targets by 2020. Moreover, these targets are also essential for the success of the SDGs and Paris Agreement. They ensure action on natural resources which provide food, water, timber, and plants as well as agricultural and cultural services that we depend on to survive. For example, the blue economy (SDG 14.2) generates at least USD 2.5 trillion a year (WWF 2019d) and it is estimated that over 3 billion people rely on oceans for their livelihoods (UN Conference on Trade and Development n.d.).

What we do with these maturing targets beyond their 2020 deadline will determine whether we maintain the ambition of the transformational agenda or compromise our vision for a sustainable and secure world. In the words of UN Deputy Secretary-General Amina Mohammed, 2019 must be the “year of transformative solutions” (Mohammed 2019) needed to halt the unprecedented effects on our natural environment which will affect our survival and well-being.

## **A New Deal for Nature and People**

We must make the most out of this unique window of opportunity. WWF is calling for a New Deal for Nature and People in 2020 that embraces a new narrative, underlining both the perils we face and outlining the path towards a more secure and sustainable future. This will be combined with an ambitious set of measurable, communicable and transformational targets, as well as robust implementation mechanisms. This New Deal must break down siloes and promote the links between climate, ocean, and biodiversity through the respective conventions/agreements, and will also be essential to achieve the 2030 Agenda for Sustainable Development.

The New Deal is an ambitious endeavour, with nothing less than the future well-being of both our societies and our planet at stake. It will inevitably require a very broad multi-sector, multi-stakeholder mobilisation and convergence, co-shaping it and driving it.

To support this, WWF International is working on refining a set of science-based targets to protect and restore nature by 2030. Initial high-level targets include:

- Halt the 6th mass extinction;
- 50% of land and sea protected, restored, or sustainably managed by 2030;
- 50% of production and consumption is sustainable by 2030.

Achieving these targets will enable food and water security for 9 billion people, ensure diversity of life, and help maintain a stable climate to support all life on Earth.

## **The time for action is now**

The science is clear: our planet is in the red. To achieve climate and sustainable development commitments, reversing the loss of nature and biodiversity is critical. The window of opportunity for an imperative course-correction is rapidly closing. And yet the undeniable truth is that we do not recognise the value of the ‘wild’ and we continue to take Nature’s services for granted.

In the past 60 years, truly a blink of an eye compared to the more than 2 million years of our species’ history, we have seen an exponential acceleration of the unsustainable and wasteful use of natural resources. Moreover, we now know that ‘business as usual’ is not an option. The cost of action is dwarfed by the cost of inaction.

In the next few years, we need to urgently transition to a net carbon-neutral society, and halt and reverse nature loss – through green fi-

nance, clean energy, and environmentally friendly food production. We must also preserve and restore enough land and ocean in a natural state.

As by far the most powerful species on Earth, we are at a crossroads: continue to develop and grow our economies at the cost of the planet, taking nature and natural resources for granted, driving ecosystems like forests, oceans, and rivers towards dangerous, irreversible tipping points and, in doing so, undermining the ecological stability of the planet and our own future; OR re-balance our relationship with the planet, co-existing in harmony with nature and the diversity of non-human life, and becoming wise, responsible stewards of the bountiful resources nature provides to us every day, for free. We have the moral duty to live in harmony with nature and the amazing diversity of life we share the planet with. Beyond that, it is clear and unmistakable that it is in our own, naked self-interest to behave in systemically more sustainable ways, before the inevitable course-correction required will be too little, too late. The price we will pay will be enormous, this we already know. Nature conservation is not only a question of morality, it is also a question of our health, wellbeing, prosperity, happiness and ultimately, survival.

To do this we need to deeply change our mind-set, the way we look at and value nature. This generation of women and men, not the next one, is the first that knows we are destroying the planet and our future, and most likely the last to be able to do something about it. A daunting challenge but also an exciting and unmissable opportunity to build a future in which people and nature thrive.

In the words of His Holiness Pope Francis “We received this world as an inheritance from past generations, but also as a loan from future generations, to whom we will have to return it” (Address of the Holy Father, San Francisco Church, Quito, Ecuador, 7 July 2015).

## Bibliography

- Bas, L. (Oct 8, 2018). *Nature-based solutions are key to achieving Europe's ambitious climate change targets*. Last accessed on September 24, 2019, at <https://www.iucn.org/news/europe/201810/nature-based-solutions-are-key-achieving-europes-ambitious-climate-change-targets>
- BBC News (March 20, 2018). Northern white rhino: Last male Sudan dies in Kenya. Last accessed on November 19, 2019, at <https://www.bbc.com/news/world-africa-43468066>
- FAO (2019). *The state of the world's biodiversity for food and agriculture* (J. Bélanger & D. Pilling, eds.). FAO Commission on Genetic Resources for Food and Agriculture Assessments: Rome. Last accessed on September 24, 2019, at <http://www.fao.org/3/CA3129EN/CA3129EN.pdf>
- Global Footprint Network (2019). *Global*

- Footprint Network: Advancing the Science of Sustainability*. Last accessed on September 24, 2019, at <http://data.footprintnetwork.org/#/>
- IPBES (May 2019). *Nature's Dangerous Decline 'Unprecedented' Species Extinction Rates 'Accelerating': Current global response insufficient; 'Transformative changes' needed to restore and protect nature; Opposition from vested interests can be overcome for public good: Most comprehensive assessment of its kind; 1,000,000 species threatened with extinction*. Last accessed on September 24, 2019, at <http://bit.ly/IPBESReport>
- IPCC (2018). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Last accessed on September 24, 2019, at [https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15\\_Full\\_Report\\_Low\\_Res.pdf](https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf)
- Lellis-Dibble, K.A., McGlynn, K.E., Bigford, T.E. (November 2008). Estuarine fish and shellfish species in U.S. commercial and recreational fisheries: economic value as an incentive to protect and restore estuarine habitat. *NAOO tech. memo NMFS-F/SPO, 90*. Last accessed on September 24, 2019, at <https://repository.library.noaa.gov/view/noaa/3612>
- Mohammed, A. (March 14, 2019). Deputy Secretary-General's remarks to Fourth UN Environment Assembly [as prepared for delivery]. Last accessed on September 24, 2019, at <https://www.un.org/sg/en/content/dsg/statement/2019-03-14/deputy-secretary-generals-remarks-fourth-un-environment-assembly-prepared-for-delivery>
- UN Conference on Trade and Development (n.d.). Oceans Economy and Fisheries. Last accessed on September 24, 2019, at <https://unctad.org/en/Pages/DITC/Trade-and-Environment/Oceans-Economy.aspx>
- University of Vermont (Nov 1, 2016). Elephant poaching costs African economies \$25 million per year in lost tourism revenue: Investing in elephant conservation is smart economic policy for many African countries. *ScienceDaily*. Last accessed on November 18, 2019, at [www.sciencedaily.com/releases/2016/11/161101153114.htm](http://www.sciencedaily.com/releases/2016/11/161101153114.htm)
- Vatican Information Service (July 8, 2015). Wednesday, July 8, 2015. Last accessed on September 25, 2019, at <http://visnews-en.blogspot.com/2015/07/to-representatives-of-civil-society.html>
- WEF (2019). The Global Risks Report 2019. 14<sup>th</sup> edition. World Economic Forum: Geneva. Last accessed on September 24, 2019, at [http://www3.weforum.org/docs/WEF\\_Global\\_Risks\\_Report\\_2019.pdf](http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf)
- Wilcox, C., Van Seville, E., Hardesty, B. D. (2015). Threat of plastic pollution to seabirds is global, pervasive, and increasing. *Proceedings of the National Academy of Sciences*, 112, 11899-11904, <https://doi.org/10.1073/pnas.1502108112>
- WWF (2016). *Living Planet Report 2016: Risk and resilience in a new era*. WWF: Gland. Last accessed on September 24, 2019, at [http://awsassets.panda.org/downloads/lpr\\_living\\_planet\\_report\\_2016.pdf](http://awsassets.panda.org/downloads/lpr_living_planet_report_2016.pdf)
- WWF (2018). *Living Planet Report 2018: Aiming higher*. WWF: Gland. Last accessed on September 24, 2018, at [https://s3.amazonaws.com/wwfassets/downloads/lpr2018\\_full\\_report\\_spreads.pdf](https://s3.amazonaws.com/wwfassets/downloads/lpr2018_full_report_spreads.pdf)
- WWF (2019a). *WWF: Deforestation and Forest Degradation: Overview*. Last accessed on September 24, 2019, at <https://www.worldwildlife.org/threats/deforestation-and-forest-degradation>
- WWF (2019b). *WWF: Beef: Impacts*. Last accessed on September 24, 2019, at <https://www.worldwildlife.org/industries/beef>
- WWF (2019c). *WWF: Forests: Overview*.

Last accessed on September 24, 2019, at <https://www.worldwildlife.org/initiatives/forests>  
WWF (2019d). *WWF: Oceans: Overview*. Last accessed on September 24, 2019, at <https://www.worldwildlife.org/initiatives/oceans>  
WWF (n.d.). About TX2. Last accessed on November 19, 2019, at <http://tigers.panda.org/tx2/>



# COMMUNITY AUTHORITY AND THE SIGNALS OF SCIENCE: NEXT STEPS IN FURTHERING THE IMPACT OF BIODIVERSITY CONSERVATION SCIENCE

PHILIPPA JANE BENSON\*

## Introduction

In a recent editorial in the journal *Science Advances* (1), Dr. Thomas Lovejoy called attention to the recent report by the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2). The evidence in the IPBES report draws from a wide range of data and rigorous analyses documenting the status of the planet’s most precious resources: fresh water, clean soils, wood, fiber and most importantly, the full registry of the genetics of biological diversity. The IPBES publication provides substantive, unequivocal evidence that, globally, the health of the planet and the ecosystems on which all species depend are declining at accelerating and unprecedented rates. The grades on the state of planetary health in the IPBES report card are abysmal. Most troubling among them are those that reflect a profound lack of recognition by world leaders of the declining health of the planet. If the planet were an individual human being, she would already be in intensive care with round-the-clock nursing. The current neglect of planetary health begs the question: Why are so many global leaders not paying attention to the screaming signals of science?

The meeting that has prompted this writing, Noah’s Arks for the 21st Century, convened by the Pontifical Academy of Sciences, brought together leaders of the world’s greatest research natural history museums, botanical gardens, and zoos. The goal of the gathering was to foster efforts and collective enthusiasm to translate science into public and policy actions that will move forward effective protection of global biodiversity and ecosystem services. Museums, botanical gardens, and zoos are indeed critical venues for public exposure regarding the stark reality of the risks we face today. Our timeline for action is very short and the stakes cannot be higher. Broad, powerful education and outreach must begin in haste, using

\* Ph.D. Managing Editor, *Science Advances*, Washington DC, USA.

today's publishing and information dissemination technologies to connect science to specific actions that anyone can take to move toward the goal of sustainable planetary practices.

### **Communities of Authority**

When human populations are understood to be directly at risk by, for example, highly infectious diseases or extreme weather, leaders *do* take notice and turn to researchers and technical experts to determine paths forward to avert worse case scenarios. Leaders and policy makers seek out the most authoritative sources to explain the elements of the problems ahead and to outline potential solutions. People deemed to be authorities in the sciences and technology are generally identified by their prowess in specific professional communities and often have achieved top positions in respected institutions of higher learning and research. And, more often than not, these experts get to these leadership positions through achievements in scientific publishing.

Getting published in influential scientific journals is no easy feat. The most impactful scientific journals in the world today publish only a very small proportion (6%–8%) of the work submitted to them. These include journals that are broad and multidisciplinary, such as *Science* or *Nature*, and equally selective journals in specialty areas including ones focused on human health and medicine, or advances in chemistry, material sciences, and economics. Few policy makers and other non-specialist readers are able to directly understand the technical analyses published in these journals; instead they trust the editors, reviewers, and publishing process of these journals to select the most impactful work, collaborate with authors to hone the articulation of findings, and then publish final versions that represent, in theory, reliable findings, facts, and conclusions. This process of selection and review of science by editors and peer reviewers creates communities of expertise and it is these discourse communities that determine what findings are, and are not, published (3–6).

Discourse communities can be thought of as groups that sprout from a connection among participants who have common interests, whether the interests are cooking, cars, karaoke, cancer, or climate. To be a viable discourse community, however, groups must share more than common interests. The fundamental glue of a discourse community is a shared set of goals and values, and a stable and agreed upon set of participatory mechanisms for information exchange (7–9). Of equal importance to a true discourse community is that it has a set of core members: the experts. It is *this* group that shapes the evolving vocabulary that defines the genre and

“style” of acceptable conversation and debate among community members. A person new to the community of conversation will not know how to converse in the style of those at the core. Some discourse communities, such as physicians or lawyers, are easy to identify because non-experts are often in need of their specialized knowledge and are exposed to their specialized language. However, although one might be able to *recognize* doctor or lawyer “speak”, that does not necessarily mean a person can understand or participate in those communities of conversation. Other discourse communities are difficult even to identify, perhaps because they’ve never gone public, or because they never coalesced their language or style, or because they are early in their evolution (7,8).

When you look at scientists in terms of discourse communities, one can see a pattern of timing between the coalition of a community of people with specific scientific interests and the creation of related scientific journals. Examples here are easy to find, starting with the founding of the Royal Society of London in 1660, followed by its first journal, *Philosophical Transactions* in 1665. Following the model of the Royal Society, groups of professional scientists outside of Europe, whether clinicians or basic researchers, began to coalesce as societies with their corollary journals. In the United States, for example, the American Chemical Society started in 1876 and launched its highly influential *Journal of the American Chemical Society* (JACS) in 1879. Similarly, the Ecological Society of America was started in 1915 and by 1917 had established its first journal, the *Bulletin of the Ecological Society of America*. The American Association for the Advancement of Science began around 1848; however, it did not have its rise in stature until the organization took on the leadership of *Science* magazine in 1880.

The creation of a professional society followed by a journal with peer review reflects the coming together of a community of interests, which in turn establishes agreed upon participatory mechanism for the discussion of ideas, and a group’s collective effort to codifying acceptable forms and styles for debate, led by its core expert leaders. The preference and practice of peer review, with all its inherent flaws, remains a central part of how ideas transform from fiction to fact (10–11).

Until relatively recently, journals were the primary mechanism of communication within scientific communities, allowing members to create and control channels for discussion and debate. Today, journals still dominate even amidst the hubbub of social media: to gain real traction, a novel idea must be accepted for assessment in a legitimate journal (ideally one that is already recognized as high impact), scrutinized there through the

gauntlet of peer review, and eventually be published for further evaluation in a broader community of readers. Examples abound of outlier ideas moving through publication into mainstream acceptance, from the earliest discoveries in astronomy, evolution, and antibiotics to advances in genetics and space science. Researchers become successful not just by elegantly addressing new research questions, but also by knowing how to successfully negotiate the publishing process as a passage of rite for entering the inner core of influencers (4–6, 11–13).

### **A Sidebar on Discourse Communities**

Figure 20.1 represents a typical cycle of how ideas might pass through different discourse communities in traditional scientific publishing starting at the inevitable beginning point of securing funding. Authors must first write up a plan for their research addressing the funder as reader. During the course of research, there is of course a tremendous amount of written communication but this work does not represent a full, new idea rich with proofs and evidence. However, when a study is complete and authors feel the work is solid enough to withstand further scrutiny, they will select a journal to submit to and then shape their scientific argument to fit the requirements of that journal. At this point, the authors shift their attention to the journal editors as readers, whom they have to please with the form and substance of their arguments. If the work passes muster with the editors as audience and moves to peer review, the authors' attention shifts yet again to the subset of the discourse community with which they must negotiate. The reviewers, anonymous or not, serve as proxies for a wider discourse community; this wider community is not the public but rather readers who have the same focused interests who want to get into the weeds of detail. When published, the authors see their work out in a broad discourse community, but depending on the journal, that community may still be quite small, specialized, and elite. With luck the work will influence the readers to think differently about a topic, to question former ways of understanding enough to pose new questions and design new studies to explore them. This cycle represents the “traditional” model that scientific ideas must go through to be vetted, to move from a new idea to an accepted idea through cycles of examination and revision led by those considered experts in a specific community.

In short, information published in scientific journals is valued because it has been systematically vetted, through recognized and agreed upon processes, scrutinized through known channels that adhere to accepted genre, styles, and vocabularies and which are led by core expert members.



**Figure 20.1.** Caption: Vetting information is Valued Information. *Source:* Author’s elaboration.

### Establishing a New Field of Science

When looking at the emergence of publishing about biodiversity and conservation science in particular, a pattern emerges similar to that seen in earlier scientific disciplines. 1970 is a reasonable starting point to look more closely at the use of the term biodiversity in scientific literature as it was that year that brought the creation of the Environmental Protection Agency, the Club of Rome, and the first recognized International Earth Day. Norman Myers published *The Sinking Ark* in 1979 (14) and Tom Lovejoy, referenced earlier, brought the term “biodiversity” squarely into the limelight in the early 1980s (15, 16). The Society of Conservation Biology started in 1985 followed by its flagship journal, *Conservation Biology* in 1987. In fact, an analysis using a popular citation database (17) shows that relatively few scientific papers used the term “biodiversity” as a keyword until the late 1980s when the term began to show up in scientific literature, aligned with the events above and with the publication of the seminal work *Biodiversity* led by E.O. Wilson and Frank Peter (18).

The increase in attention to the study of biodiversity and its relationship to planetary health was also reflected in the creation of the Intergovernmental Panel on Climate Change (IPCC), the precursor to the IPBES,

in 1988. The IPCC was created by two organizations [the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)] to assess the latest science related to climate change, and then to deliver compiled findings in a format digestible to policy makers and the public. The IPCC did not convene as a professional scientific society per se and rather focused on assessing scientific, technical, and socioeconomic information relevant to understanding the risks of human-induced alterations to climate. Unlike traditional scientific societies, the IPCC does not support new research or evaluate or publish new data. Instead, its assessments are grounded in the peer-reviewed scientific and technical literature that is reviewed, published, and curated by others.

In other words, despite the wide recognition of the value and integrity of the IPCC reports, the group is young relative to other authoritative scientific discourse communities. Although it has a scientific focus and some mechanism for communication and debate, it does not represent the scientists whose work it brings into public view. Neither the IPCC nor the IP-BES have yet evolved into a recognized, authoritative community of experts on the combined diagnostics of planetary health drawn from biodiversity and related climate science. The result of this is in part the reality that the public does not yet hold scientists in these fields in the same esteem as they do medical doctors, physicists, or engineers. Scientists working in this area are only beginning to hit the public radar as authorities because the symptoms of planetary illness – heat, drought, extreme weather – are becoming extreme and threatening, and therefore getting people’s attention.

### **It Is All About Metadata**

In the same general time frame that the term biodiversity started to become more frequent in scientific literature, there was also an extraordinary proliferation of databases related to biodiversity and geographic information, and biological nomenclature (19). These ranged from early efforts (e.g., 1985 Taxonomic Databases Working Group, 1992 Canabio, 1996 Fishbase) to the now defunct National Biological Information Infrastructure. From those grew the Darwin Core (a standard glossary of terms created and maintained to facilitate the sharing of information about biological diversity), the Global Biodiversity Information Facility, and the consortium for the Bar Code of Life, launched in 2004. By 2009, the Darwin Core initiated the first standards for metadata related to biodiversity conservation.

I note the publishing of these biological nomenclature standards as particularly important because the standards used in these databases are dif-

ferent, in part at least, due to those used more generally in scientific publishing. On the one hand scientific publishers have their own very widely used bibliographic data standards, those established by the National Library of Medicine, now referred to as the Journal Article Tag Suite, or JATS (20). These tags not only allow extremely rapid conversion of text format from a document to a variety of digital forms but are used by a variety of powerful tools to make the content digitally findable and therefore easy to be collected and organized by different kinds of search engines. Journal article tags are the tools that allow users to find the information they want as the first step in understanding and use. As the volume of data documenting biodiversity explodes, researchers have recognized the critical importance of aggregating and aligning biodiversity data.

Advancing knowledge of global biodiversity and the implications of its destruction will require strident efforts to integrate biological, geographic, and other data on the informatics level. Researchers and funders will need to make concerted effort to make core literature findable by researchers, policymakers, and the public. Critical among these tools is the Digital Object Identifiers (DOI), which allow librarians and users alike to track and manage intellectual objects from data to figures to journal articles to eBooks and beyond, through persistent, interoperable identifiers for each distinct piece of content (21).

Organizations curating DOIs have made them completely affordable for large and small publishers alike. Unfortunately, many organizations that publish critical biodiversity data and analysis as grey literature, have not yet incorporated this essential step in making their data and analyses available to others (21). In neglecting the affordable tools of modern electronic publishing, these organizations not only diminish the authority of their work, but also are functionally declining to join the movement to make science transparent, open, and reproducible.

It would be ideal if scientists and publishers are all on the same page and working together in a close knit, harmonious discourse community toward the greater good of scientific endeavor, but historically this has not been the case, particularly when it comes to data. Scientists have been brought kicking and screaming into the age of reproducibility, bemoaning journal requirements not just to share data on which a particular piece of research is based, but to actually put the data in perpetuity in an open, public repository (22, 23). Although many scholarly authors support the ideals of transparency and reproducibility in science, more than a few require moderate cajoling to format and deposit their data in a public forum such as Figshare

or Github. The issue of furthering reproducibility in biodiversity science is a huge and critical topic (24), but outside this discussion.

### What Next?

At the same time, the channels for communication are proliferating: blogs, Facebook, Twitter, Instagram and in short order, journal may no longer rule. Some believe that is the case already. The list of alternates keeps growing and therefore it is becoming increasingly difficult for readers to distinguish what channels are authoritative and trustworthy and those that are not. To be effective in convincing the public and policymakers that we are already in the time frame of a planetary crisis, all those involved in biodiversity science, from the field research to the heads of museums, zoos, and gardens must work together to establish a recognizable discourse community which will in turn support their recognition as experts in planetary health. Then, as those experts, researchers must focus on collecting and standardizing the data we need to understand the specificity of species and the workings of ecosystems and this standardizing *must* be done in tandem with publishers and publishing technologies.

### Bibliography

1. Lovejoy, T. (2019). Eden no more. *Science Advances*, 5(5), eaax7492. <https://doi.org/10.1126/sciadv.aax7492>
2. IBES (2016). *Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IBES) on pollinators, pollination and food production* (Potts et al., eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: Bonn, Germany. Last accessed on September 26, 2019, at [https://www.ipbes.net/system/tdf/spm\\_deliverable\\_3a\\_pollination\\_20170222.pdf?file=1&type=node&id=15248](https://www.ipbes.net/system/tdf/spm_deliverable_3a_pollination_20170222.pdf?file=1&type=node&id=15248)
3. Nicholas, D., Watkinson, A, Jamali, H.R., Herman, E., Tenopir, C., Volentine, R., Allard, S., Levine, K. (2015). Peer review: still king in the digital age. *Learned Publishing*, 28(1), 15–21. <https://doi.org/10.1087/20150104>
4. Benson, P. and Silver, S. (2013). *What Editors Want: An Author's Guide To Scientific Journal Publishing*. University of Chicago Press: Chicago.
5. Wilsdon, J. et al. (2011). *Knowledge, networks and nations: global scientific collaboration in the 21st century*. The Royal Society: London. Last accessed on September 26, 2019, at <https://www.snowballmetrics.com/wp-content/uploads/4294976134.pdf>
6. Johnson, R., Watkinson, A., Mabe, M. (2018). *The STM report. An overview of scientific and scholarly publishing*. 5th Ed. International Association of Scientific, Technical and Medical Publishers: The Hague.
7. Swales, J. (1990). *Genre analysis: English in academic and research settings*. Cambridge University Press: New York.
8. Duszak, A., 1997. Cross-cultural academic communication: A discourse-commu-



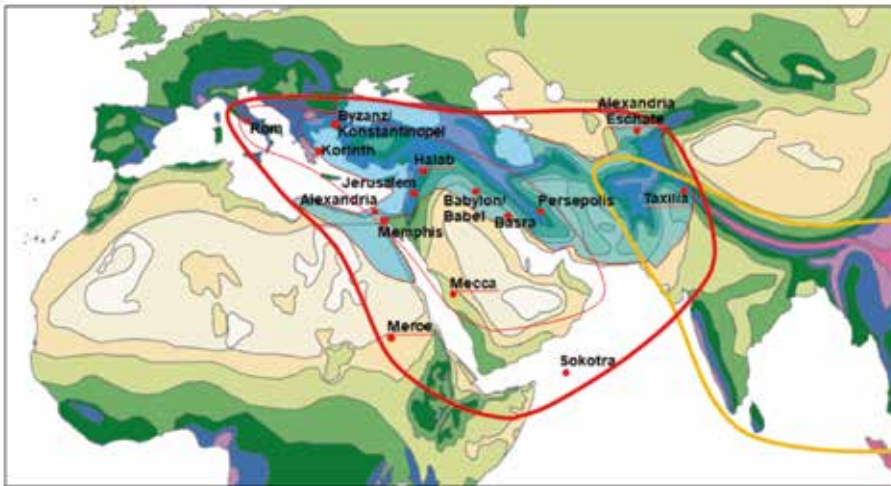
- nity view. In A. Duszak (ed.), *Culture and styles of academic discourse* (Trends In Linguistics. Studies And Monographs, Vol. 104). Mouton de Gruyter: Berlin, 11-39.
9. Atkinson, D. (1998). *Scientific discourse in sociohistorical context: The Philosophical Transactions of the Royal Society of London, 1675-1975*. Routledge: New York/London.
  10. Baldwin, M., (2015). Credibility, peer review, and Nature, 1945-1990. *Notes and Records*, 69, 337-352. <https://doi.org/10.1098/rsnr.2015.0029>
  11. Penrose, A. and Katz, S. (2010). *Writing in the sciences: Exploring conventions of scientific discourse* (3rd Ed., The Allyn & Bacon Series in Technical Communication). Pearson Longman: New York.
  12. Schriver, K.A. (1997). *Dynamics in document design: Creating text for readers*. John Wiley & Sons: New York.
  13. Schriver, K.A. (2017). Plain language in the US gains momentum: 1940-2015. *IEEE transactions on professional communication*, 60(4), 343-383.
  14. Myers, N. (1979). *The Sinking Ark. A New Look At The Problem Of Disappearing Species*. Pergamon Press: New York.
  15. Soule, M., & Wilcox, B. (1980). *Conservation Biology: An Evolutionary-Ecological Perspective*. Sinauer: Sunderland, MA.
  16. Lovejoy, T. et al. (1986). Edge And Other Effects Of Isolation On Amazon Forest Fragments. In Soulé, M.E. (ed.), *Conservation biology: the science of scarcity and diversity*. Sinauer: Sunderland, MA, 257-285.
  17. Anderson, K. (2010). Digital Science: Big Data and Diversified Risk. *Scholarly and Research Communication*, 10(1). <http://doi.org/10.22230/src.2019v-10n1a321>
  18. Wilson, E.O. and Peter, F. (1988). *Biodiversity*. National Academy of Sciences: Washington.
  19. Ball-Damerow, J. et al. (2019). Research applications of primary biodiversity databases in the digital age. *BioRxiv*, 605071. <https://doi.org/10.1101/605071>
  20. Beck, J. (2011). NISO Z39. 96 The Journal Article Tag Suite (JATS): What Happened to the NLM DTDs? *Journal Of Electronic Publishing*, 14(1). <http://dx.doi.org/10.3998/3336451.0014.106>
  21. Paskin, N. (2010). Digital object identifier (DOI®) system. *Encyclopedia of library and information sciences* (3rd ed.) <https://dx.doi.org/10.1081/E-ELIS3-120044418>
  22. Haddaway, N.R., Collins, A.M., Coughlin, D., Kirk, S. (2015). The role of Google Scholar in evidence reviews and its applicability to grey literature searching. *PloS One*, 10(9), e0138237. <https://doi.org/10.1371/journal.pone.0138237>
  23. Goodman, S.N., Fanelli, D., Ioannidis, J.P.A. (2016). What does research reproducibility mean? *Science Translational Medicine*, 8(341), 341-343. <https://doi.org/10.1126/scitranslmed.aaf5027>
  24. Nosek, B.A et al. (2015). Promoting an open research culture. *Science*, 348(6242), 1422-1425. <http://dx.doi.org/10.1126/science.aab2374>
  25. Stodden, V., Seiler, J., Ma, Z. (2018). An empirical analysis of journal policy effectiveness for computational reproducibility. *Proceedings of the National Academy of Sciences*, 115(11). <https://doi.org/10.1073/pnas.1708290115>

## PLANTS AND NATURE IN BIBLE AND QURAN. HOW RESPECT FOR NATURE CONNECTS US

WILHELM BARTHOLOTT\*

### Introduction

Plants and nature play an important role in the Holy Scriptures of both Christians and Muslims – associated in both religions with the task of preserving Creation and exemplified in the parable of Noah’s Ark, which is found to be almost identical in the Bible and the Quran. As far as we can allocate the Hebrew-Aramaic and Arabic names to botanical species, these species, with few exceptions, are mostly identical in both scriptures. All of this is not surprising, considering that, including Judaism, the three monotheistic religions, which refer to the God of Abraham, all emerged from the narrowly defined semiarid region of the oasis-civilizations between the Tigris, Euphrates, and Nile rivers (Figure 21.1). Biogeographically, this is the natural distribution range of the date palm (*Phoenix dactylifera*). One



**Figure 21.1.** Geographical origin of the Bible and the Quran. *Note:* The red line marks the area which Judaism, Christianity, and Islam originated from. The yellow line depicts the area of Hinduist and Buddhist origin. *Source:* Barthlott (2019) based on Barthlott & Rafiqpoor (2016).

\* Prof. em. Nees-Institute for Biodiversity of Plants, University of Bonn, Germany.

may also consider the spatial proximity (the distance between Jerusalem and Medina is only about 900 km) and the historically rather short time frame in which these core texts emerged: The selection and final version of our modern Bible texts took place in Alexandria AD 375, the central Christian doctrine of the Trinity was dogmatized in Toledo AD 675, that is, only after the revelation of the Quran had been completed AD 632.

However, in the history of the monotheistic religions, nature has played a secondary role. The natural world was often primarily seen as a set of resources for human utility (White 1967). Only after the anticipated extent of global environmental changes (e.g. Meadows et al. 1972, Rockström et al. 2009) became apparent, did the religions elicit their task of preserving Creation and the environment (e.g., Assisi Declarations 1986; Pope Francis 2015, Islamic Declaration on Global Climate Change 2015; cf. Pye et al. 1997, Alt 1999, Grim & Tucker 2014, Jenkins et al. 2017). The encyclical by Pope Francis (2015) in particular, was a fundamental waking call – and highly important for the mutual respect among the Abrahamic religions – as it resembled a milestone in a process, which had commenced only late in history with the Second Ecumenical Council (1962–1965).

Religions shape our values and culture and determine the actions of most people. Natural science can only deliver data and recommend actions; however, society, media and education, politics, sentimentalities and ideologies decide. About 75% of the Earth's population (currently ca. 7.6 bn people) are affiliated with one of the four most prevalent religions (Christianity ~2.3 bn., Islam ~1.8 bn., Hinduism ~1.1 bn., Buddhism ~0.5 bn.) according to recent figures published by the Pew Research Center (2017).

The majority of the Earth's population has therefore – at least theoretically – a common goal: the preservation of nature. However, whether or not this preservation is pursued, depends on the prerequisite that we are able to learn to treat each other with mutual respect and empathy and that we give up on our claim to sole ownership of truth. In the following, this essay does not aim to provide botanical lists of the plants of the holy scriptures; rather, it focuses on answering the question how respect for nature *could* connect us (cf. Barthlott 2018 and 2019).

### **Plants and nature in the Scriptures**

The Abrahamic religions (Judaism, Christianity, and Islam) emerged from similar cultural traditions in a rather short historical time frame, biogeographically within the natural distribution range of the date palm, in a narrowly defined area of the oasis cultures of the semiarid region between

the Indus valley and the Tigris, Euphrates, and Nile rivers (Figure 21.1). The Jewish Torah forms a central part of the Old Testament, and much of the Quran refers to both the Old and New Testament. The commonalities of Bible and Quran are vast; the few differences, however, fundamental.

In the Old and New Testament, a large diversity of plant names is listed. In a long historical tradition starting long before Linnaeus' work for the Swedish Bible commission in the late 18th century, one assumed to be able to identify several hundred different species in the Aramaic, Hebrew, and Greek texts. For the Bible, popular science books and internet websites list hundreds of different plants (see, e.g., lists of Bible plants on Wikipedia). However, with some confidence, fewer than 60 names can be assigned to defined botanical species. The list of publications on this topic is long, with analyses provided by various authors (Moldenke & Moldenke 1952, Zohary 1983, Stückrath 2012, Musselmann 2012, Barthlott et al. 2016).

Often, there are less scientific than philological and cultural-historical aspects that allow to identify a Bible plant as a certain botanical species. Bible and Quran are written in the closely related Semitic languages: Aramaic, Hebrew, and Arabic. On a purely quantitative level, the Quran (McAuliffe 2006) is less comprehensive than the much longer texts of the Bible and, for several reasons, fewer scientific analyses are available: There are some 20 names in the Quran, which, with few exceptions, seem to be more or less identical with plants in the Bible. Overviews are given by Musselman (2007), Ahmad et al. (2009), Al-Khulaifi and El-Gharib (2015), and Barthlott et al. (2016) (cf. also Ghazanfar & Fischer 2013).

Generally, the plants mentioned in the two scriptures can be divided into three main groups. Dominating are economic and medical plants in the widest sense, ranging from grains, figs, dates, papyrus, and cedars to perfumes and incense plants such as frankincense or spikenard. A second group of conspicuous, often attractive plants, usually are flowers (the “flowers of the fields” or “lilies of the valleys”) which can rarely be unequivocally assigned to botanical entities.

The third group are symbolic plants such as the Tree of Knowledge of Good and Evil found in the Paradise of both the Bible and the Quran, which is certainly not the apple tree and probably not the fig or pomegranate tree, but might rather be the grape vine, which, during the antiquity, was classified as a tree. Pliny the Elder discusses this extensively in his *Naturalis Historia*. Wine is ambivalently good and bad in both the Bible and the Quran – according to the Quran, there are rivers of wine in paradise (Surah 16). The two Holy Scriptures express the belief that drinking wine

allows to distinguish between good and evil (Herodotus about the Persians, see Tree of Knowledge cf. Genesis 2,9 and Surah 7) and the Bible additionally compares this action to drinking blood (Androkydes to Alexander the Great, cf. Last Supper or Deuteronomy 32).

Environmental change commenced early and is reflected already in the Bible (Sperber 1994). Two examples may elucidate this: Papyrus (*Cyperus papyrus*) originated in tropical East Africa and was distributed along the Nile until reaching the Mediterranean coast. It is one of the oldest useful plants connected to our cultures as writing material (“paper”) or to building boats, which were able to cross the Atlantic (see Thor Heyerdahl’s boat “Ra II”). The history of young Moses exposed in a reed box appears in the Bible and in the Quran – nevertheless, this box is more likely to have been a small papyrus construction (Zohary 1983). The history of the Exodus from Egypt, which is told almost identically in the Bible and the Quran, does not refer to the Red Sea, but to the endless *Papyrus* and reed swamps in the North Eastern delta of the Nile. The Hebrew texts clearly call it a swamp or “sea of reed” (Yam Suph יַם-סוּף), extensive *Papyrus* swamps, which are known today as “Sudd” from the White Nile in South Sudan. *Papyrus* is an astonishing example for early environmental change brought about through intense human activities (agriculture and drainage) in the last 5,000 years. Already in the time of the Egyptian campaign of Napoleon (1798-1801), *Papyrus* was no longer found in its native habitat. The last report on finding actual *Papyrus* dates from 1821 and refers to the region of Port Said (Serag 2003) along the route which Moses probably took. The Nile delta variety of *Papyrus* was obviously re-introduced in the middle of the 20th century, probably originating from the Botanical Gardens of Luxemburg. This act reflects an interesting example for the role of living collections for the preservation of nature.

The sacred lotus *Nelumbo* has a similar history. Probably of Chinese origin, it came via the Indus valley and arrived in the Nile region about 600 BC, only to disappear again from Egypt around 1100 AD, owed to the extensive cultivation of sugar cane (*Sacharum* is a Southeastern Asian plant, probably of New Guinean origin). *Nelumbo* was ascribed high symbolic value due to its conspicuous flowers and additionally was an economically valuable plant, which due to its edible seeds was also referred to as *Fabae aegyptiae*, Egyptian beans.<sup>1</sup> Both aspects make it almost certain that *Nelumbo* is

<sup>1</sup> In his *Naturalis Historia*, Pliny the Elder provides for a detailed description of the *Nelumbo* harvest from the Nile delta around Alexandria.

mentioned in the Bible – yet we do not know under which name (perhaps the expression “*lily of the valley*” refers to it). The history of the lotus is most confusing (cf. Woenig 1897, Bretzel 1903), because the name “Lotus” is used also for two species of *Nymphaea* (*N. lotus*, *N. caerulea*) of the Nile. Homer (e.g., Odysseus and the lotus-eaters) mentions lotus at least seven times and, apparently, uses this term to refer to different plants, ranging from grasses to trees (Herzhoff 1984) – thus confirming the modern hypothesis, that Homer is a collective name for several authors. Lotus, with its wasp nest-like fruits, which Herodotus already listed, easily identifiable under the name *krinos* (Lily), was considered a symbol of purity in Hinduism and later also in Buddhism – the super-hydrophobic leaves became the model for the high technology of the *Lotus-Effect* (Barthlott & Neinhuis 1997). Presumably, the purity of the *Nelumbo* / “Lily” continues to live on under its Semitic name in the parable of *Susanna* and the Elders, and possibly even as the white lily, the symbol of purity of the Immaculate Conception in the Christian tradition.

In translating the Bible into modern languages, species names are often chosen rather arbitrarily, thus corresponding mainly to the preferences and fashion of the current epoch. A good example for this is the modern translation of (e.g. German unified bible translation) “pigeon droppings” in 2 Kings 6:25 as “*Milchstern*” (“Star of Bethlehem”, i.e. *Ornithogalum*), based on a misinterpretation of Linnaeus’ work for the Swedish Bible commission in the 18th century. However, it may be more reasonable to take the text literally: Up to the middle of the 19th century, dried pigeon droppings were used as an organic leavening-agent and were thus, for example, an essential component in bread making (Von Rumohr, 2010).

In the Arabic Quran, these problems in translation seem not to exist. Nevertheless, the modern reader needs an interpretation and exegesis as of how the 7th century Arabic terminological references to plants and animals could or should be understood. Every text needs its exegesis.

Furthermore, many of the plants and animals that were of economic interest in the antiquity did not originate in the area in which the Bible and the Quran were written, but rather came from faraway places. Sugar cane (presumably from New Guinea), chickens (presumably from Polynesia), and the lotus flower (presumably from China) were already known in the Middle East during the times that the writings of the Old Testament or rather the Tanakh were compiled. Linnaeus had failed to recognize that the names of plants in the Bible did not necessarily refer to the native flora of Palestine as his interpretations largely disregarded the variety of plants found in the region due to cultural and economic connections.

In both religions, Christianity and Islam, century-old associations of plants play an important role. However, the terminology used in the Holy Scriptures does not necessarily match today's botanical terminology. In this way, it is strongly unlikely that Boxwood (*Buxus sempervirens*) or Madonna lilies (*Lilium candidum*) were actually referred to in the Bible; the same applies to the rose in the Quran. Rather it is necessary to differentiate between the original texts and the millennia-long traditions of religions (cf. e.g. Schimmel 2001).

Both symbolic and useful plants dominate the canonical texts and, at times, are identifiable as a certain botanical species. The date palm (*Phoenix*), for example, may function as a biogeographic symbol of the three Abrahamic religions. Date palm, dromedary and lion are the three dominant elements on a robe (Figure 21.2) that emperors of the Holy Roman Empire wore during their coronation ceremonies. It was originally made for Roger II and was worn by the European emperors for over six centuries until the end of the empire in 1806. This garment is of Arabic-Sicilian origin and includes encircling Arabic text, which dates back to the year of Hedschra 528, that is, to 1133/1134 AD.



**Figure 21.2.** Coronation robe of the Emperors of the Holy Roman Empire. *Note:* The robe is displayed at the Kaiserliche Schatzkammer in Vienna, Austria. *Source:* Photo by Dennis Jarvis titled “Coronation Mantle – Palermo, Royal Court Woorkshop [sic] – 1133/34”.<sup>2</sup>

<sup>2</sup>This photo was incorporated without changes under CC BY-SA 2.0. It is available at [https://commons.wikimedia.org/wiki/Category:Coronation\\_Mantle\\_of\\_the\\_Holy\\_Roman\\_Empire#/media/File:Austria-03366\\_-\\_Coronation\\_Mantle\\_\(32936320465\).jpg](https://commons.wikimedia.org/wiki/Category:Coronation_Mantle_of_the_Holy_Roman_Empire#/media/File:Austria-03366_-_Coronation_Mantle_(32936320465).jpg) (last accessed on November 8, 2019).

### Respect for nature connects us: Noah or Nuh is only one of many examples

If we see beyond our own cultural imprint, we notice how much agreement there is between Christianity and Islam. In fact, Islam was considered to be a heretic form of Christianity up to the Reformation as expressed, for example, by John of Damascus and Niclas of Cusa (Fletcher 2002). Almost the same parables are used in the Bible and the Quran (cf. synoptic survey in Thyen 2015), the story of the Genesis is almost identical in every detail, the Virgin Mary is the mother of the venerated prophet Jesus, etc. – the fundamental difference being the mystery of the Trinity. This becomes evident in Surah 112 of the Quran, one of the core Surahs to characterize Allah, which reads: “He is Allah, [who is] One, Allah, the Eternal Refuge. He neither begets nor is born”. Goethe masterfully interpreted this image of God in an unpublished poem associated with his *West-Eastern Divan*, thus bridging the Christian and Islamic tradition by referring to Jesus and Muhammad, respectively: “Jesus purely, thoughtful, awed, / Felt One God, when all was still. / Who’d make Jesus into God / Would put pain his holy will. // Right it seems, and bright as sun – / What Muhammad knew so well; / Through the concept of the One / All the world could he compel”. (Goethe 2010, p. 169).

However, as far as the aspect of nature conservation is concerned, there are obviously no differences in the two Scriptures. The most impressive example for the mission to safeguard creation is the parable of Noah’s Ark in the Bible and the Quran (Figure 21.3). It also shows the deep historical background of many such texts: The myth is older than the Old Testament and was first written down about 3,500 years ago in the Atrahasis Epic and subsequently in the Epic of Gilgamesh. The flood and the Ark, combined with the divine task to preserve diversity, are found again not only in the Old Testament (Genesis 6,9) but with almost the same wording in the Quran (Surah 11,44), which equally refers to Noah (Arabic: Nuh). The flood myth is found again in a very similar form in Greek mythology, in the parable of Deucalion, who, by the order of a God (Prometheus), builds an ark to safeguard life from a flood. The original texts are dated around 1600 BC – just like the Tempest Stele of pharaoh Ahmose I found in the temple of Karnak at Thebes, or the Ipuwer Papyrus (Papyrus Leiden I 344). All these mythological adaptations (cf. Finkel 2014) probably have their origin in the context of a catastrophic volcanic eruption on the island of Santorini and a subsequent tsunami about 3,600 years ago. The explosive eruption of a volcano can cause global climatic disturbances: The eruption of the volcano Tambora in Indonesia in 1815, for example,



lead to subsequent catastrophic climatic disturbances that even affected Europe and North America (Behringer 2015). However, perhaps the most important message for the conservation of biodiversity can be derived from the parable of the Tower of Babel: Humans are to respect the limits to growth.



**Figure 21.3.** Noah's Ark or Nuh's Ark is a central myth of the three Abrahamic Religions. *Source:* Woodcut from *Cosmographie Universelle*, Paris 1575, incorporated from Barthlott (2019).

### How respect for nature could connects us

Obviously, all major religions fundamentally agree to protect nature. Herein we may find a key for the successful preservation of our environment. The professing atheist and president of the British Science Association Robert May has summarized this according to a much-read article in *The Telegraph* (Alleyne 2009) by stating: "Maybe religion is needed" and "A supernatural punisher maybe part of the solution [of climate change]". Said article continues to explain that May contemplated the belief in a supernatural entity as a contributing evolutionary mechanism to foster cooperation through the fear of punishment. In this way, religious teachings and belief could benefit the protection of this planet and the conservation of

all life on Earth, especially if political leaders and governments are hesitant to implement the means of the worldly realm.

We live today in an over-populated and complexly interactive “full world”, that is, humankind and our artifacts have replaced untouched nature and resources that once were part of the “empty world” of our forebearers (Daly 2005). What has brought us to this point, has been coined as “uneconomic growth” and defined as “increases in production [...] at an expense of resources and well-being that is worth more than the items made” (Daly 2005, p. 103). In this “full world”, the philosophies of the Enlightenment of the “empty world” are of limited value (e.g. Weizsäcker & Wijkman 2017). Rousseau, Voltaire, Hume, and Spinoza are valid only in a restricted way in today’s digitalized and globalized full world. The old principle of “growth is progress” is no longer valid – we remember the parable of the Tower of Babel. With the beginning of the Anthropocene, we have clearly reached an existential limit (cf. Pope Francis 2015); climate change is only one alarming signal of the human-made environmental pollution and destruction that is brought about by uneconomic growth (Daly 2005).

What unites the overwhelming part of the world’s population are the Abrahamic religions and their goals, such as their mission to preserve Creation. If they and the Western democracies overcome their claim to sole ownership of truth, a basis for communication and common actions in the sense of the Bible and the Quran could be created. Communication between all cultures, ethnicities, religions, and nations, empathy for one another, and the respectful dialogue between East and West and North and South at eye level are the prerequisite for an interconnectedness in diversity that matches both our biological diversity and interdependence. Highlighting the role of religious belief not just in the God of Abraham but in nature as a manifestation of the supernatural, may be the key to integrating the religiously oriented 75% of the world’s population, who according to their belief should be in favor of protecting nature.

The two closely related Abrahamic religions of Christianity and Islam are prepared to play a crucial role in achieving this core objective. Historical milestones for taking responsibility for the preservation of nature and the environment were the Assisi Declarations from 1986 and the encyclical *Laudato si’* by Pope Francis (2015) as well as, in the same year, the *Islamic Declaration on Global Climate Change*. Undoubtedly, Pope Francis’ encyclical has outlined the essence of the current global crisis and simultaneously identified solutions. As Nicholas of Cusa once stated: “*Eadem spectamus astra*” – we all look up to the same stars. Yet, we still look for the divisive and

accept only very limited differences in the diversity of religions, cultures and political systems in the world. Biodiversity is diversity of life, which is reflected in the many species mentioned in the Bible and the Quran. Maintaining and caring for our “common home” demands respect, empathy, and dialogue. Jointly pursuing this common interest is the great opportunity in the 21st century – not just for ecology and nature conservation but also for our all-encompassing interconnectedness.

## Bibliography

- Ahmad, M, Khan, M.A., Marwat, S.K. (2009). Useful Medicinal Flora Enlisted in Holy Quran and Ahadith. *American-Eurasian J. Agric. & Environ. Sci.*, 5(1), 126–140.
- Al-Eisawi, D.M. & S. Al Ruzayza (2015). The Flora of holy Mecca district, Saudi Arabia. *International Journal of Biodiversity and Conservation*, 7(3), 173–189. <https://doi.org/10.5897/IJBC2014.0773>
- Al-Khulaifi, F. & A. El-Gharib (2015). *Illustrated Book of the Plants of the Qur’anic Botanic Garden*. Qatar Foundation: Doha.
- Alleyne, R. (2009). Maybe religion is the answer claims atheist scientist. *The Telegraph*. Last accessed on October 7, 2019, at <https://www.telegraph.co.uk/journalists/richard-alleyne/6146656/Maybe-religion-is-the-answer-claims-atheist-scientist.html>
- Alt, F. (1999). *Der ökologische Jesus – Vertrauen in die Schöpfung*. Mit einem Vorwort von Klaus Töpfer. Reimann Verlag: München.
- Assmann, J. (2016). *Totale Religion. Ursprünge und Formen puritanischer Verschärfung*. Picus Verlag: Wien.
- Assisi Declarations (1986). *Messages on Humanity and Nature from Buddhism, Christianity, Hinduism, Islam & Judaism*. Alliance of Religions and Conservation (ARC): Bath, UK. Last accessed on September 26, 2019, at <http://www.arcworld.org/downloads/THE%20ASSISI%20DECLARATIONS.pdf>
- Barthlott, W. (2018). *Ökologie und Religion – Über die Potenziale einer mächtigen Partnerschaft*. In *Jahrbuch für Ökologie 2017/2018*, Hirzel Publishers: Stuttgart, 103–117.
- Barthlott, W. (2019). *Naturschutz und Religion – Gedanken zu einer mächtigen Partnerschaft beim Erhalt der Biodiversität*. Ein streitbares Essay. *Koenigia* 13(11), 35–42. Last accessed on September 26, 2019, at [http://www.lotus-salvinia.de/images/PDF\\_Publication/462\\_Barthlott\\_2019\\_Koenigia.pdf](http://www.lotus-salvinia.de/images/PDF_Publication/462_Barthlott_2019_Koenigia.pdf)
- Barthlott, W. & C. Neinhuis (1997). Purity of the sacred lotus, or escape from contamination on biological surfaces. *Planta*, 202(1). 1–8. <https://doi.org/10.1007/s004250050096>
- Barthlott, W. & M.D. Rafiqpoor (2016). Biodiversität im Wandel – Globale Muster der Artenvielfalt. In Lozán J.L., S.-W. Breckle, R. Müller & E. Rachor (Eds.), *Warnsignal Klima: Die Biodiversität: Berücksichtigung von Habitatveränderungen, Umweltverschmutzung & Globalisierung*. Verlag Wissenschaftliche Auswertungen / GEO: Hamburg, 44–50.
- Barthlott, W., J. Obholzer & M.D. Rafiqpoor (2016). *Pflanzen der Heiligen Bücher Bibel und Koran*. BfN-Skript 448. Bundesamt für Naturschutz: Bonn. Last accessed on September 26, 2019, at <https://www.bfn.de/fileadmin/BfN/service/Dokumente/skripten/Skript448.pdf>
- Behringer, W. (2015). *Tambora und das Jahr ohne Sommer. Wie ein Vulkan die Welt in die Krise stürzte*. Beck: München.

- Bretzel, H (1903). *Botanische Forschungen des Alexanderzuges*. B.G. Teubner: Leipzig.
- Boulos, Loutfy (1999-2005). *Flora of Egypt* (4 Vols). Al Hadara Publishing: Cairo.
- Daly, H.E. (2005). Economics in a full world. *Scientific American*, 293, 100-107. Last accessed on October 8, 2019, at [https://steadystate.org/wp-content/uploads/Daly\\_SciAmerican\\_FullWorldEconomics.pdf](https://steadystate.org/wp-content/uploads/Daly_SciAmerican_FullWorldEconomics.pdf)
- Davis, P. (1966-1985). *Flora of Turkey* (6 Vols). Edinburgh University Press: Edinburgh.
- Fauvelle, F.-X. (2013). *Le Rhinocéros d'Or: Histoire du Moyen Age africain*. Alma Editeur: Paris.
- Finkel, I. (2014). *The Ark before Noah: decoding the story of the flood*. Hodder & Stoughton, London.
- Fletcher, R. (2002). *The Cross and the Crescent: Christianity and Islam from Muhammad to the Reformation*. Penguin Books Ltd: London.
- Freely, J. (2009). *Aladdin's Lamp*. Knopf: New York.
- Frie, E. (2017). *Die Geschichte der Welt neu erzählt*. C.H. Beck: München.
- Ghazanfar, S. & J. Edmondson (Eds.) (1998-2016). *Flora of Iraq* (5 Vols.). Ministry of Agriculture, Iraq and Royal Botanic Gardens: Kew.
- Goethe, J.W. von (2010). *West-East Divan: The Poems, with 'Notes and Essays': Goethe's Intercultural Dialogues* (transl. by M. Bidney). State University of New York Press: Albany, NY.
- Gottlieb, R.S. (2003). *This Sacred Earth – Religion, Nature, Environment*. Routledge: London, UK.
- Grim, J. & M.E. Tucker (2014). *Ecology and Religions*. Island Press: Washington, DC.
- Herzhoff, B. (1984). Lotus – Botanische Beobachtungen zu einem homerischen Pflanzennamen. *Hermes*, 112(3), 257-271. Last accessed on September 26, 2019, at <https://www.jstor.org/stable/pdf/4476378.pdf>
- Islamic Declaration on Global Climate Change (2015). Islamic Foundation for Ecology and Environmental Sciences IF-EES/EcolIslam, Istanbul. Last accessed on September 26, 2019, at [http://www.ifees.org.uk/wp-content/uploads/2016/10/climate\\_declarationmMWB.pdf](http://www.ifees.org.uk/wp-content/uploads/2016/10/climate_declarationmMWB.pdf)
- Jenkins, W.J., M.E. Tucker & J. Grim (2017). *Routledge Handbook on Religion and Ecology*. Routledge: New York.
- Konisky, D.M. (2018). The greening of Christianity? A study of environmental attitudes over time. *Environ. Polit.* 27(2), 267-291. <https://doi.org/10.1080/09644016.2017.1416903>
- McAuliffe, J.D. (Ed.) (2006). *The Cambridge Companion to the Quran*. Cambridge University Press: Cambridge.
- Meadows, D.H., D.L. Meadows, J. Randers & W.W. Behrens III (1972). *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. Universe Books: New York, NY.
- Micksch, J., J. Khurshid, H. Meisinger & A. Mues (2015). *Religionen und Naturschutz: Gemeinsam für biologische Vielfalt*. BfN-Skript 426. Bundesamt für Naturschutz: Bonn.
- Miller, A.G., Coe, T.W. & A. Nyborg (1998-2008). *Flora of the Arabian Peninsula and Socotra* (5 Vols.). Edinburgh University Press: Edinburgh.
- Moldenke, H.N. & A.L. Moldenke (1952). *Plants of the Bible*. Chronica Botanica Co.: Waltham, Mass.
- Musselman, L.J. (2007). *Figs, Dates, Laurel and Myrrh – plants of the Bible and the Qur'an*. Timber Press: Portland, Oregon.
- Musselman, L.J. (2012). *A Dictionary of Bible Plants*. Cambridge Academic Press: Cambridge. <https://doi.org/10.1017/CBO9781139035323>
- Pew Research Center (April 5, 2017). *The Changing Global Religious Landscape*. Last accessed on October 8, 2019, at <https://www.pewforum.org/2017/04/05/>

- the-changing-global-religious-landscape/Pope Francis (2015). Encyclical letter *Laudato si'* of the Holy Father Francis on care for our common home. Vatican Press: Vatican City. Last accessed on September 26, 2019, at [http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco\\_20150524\\_enciclica-laudato-si\\_en.pdf](http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si_en.pdf)
- Pye, M., C. Kleine & M. Dech (1997). Ökologie und Religionen. Eine religionswissenschaftliche Darstellung. Marburg Journal of Religion, 2(1). <https://doi.org/10.17192/mjr.1997.2.3774>
- Raven, P.H.I. (2016). Our World and Pope Francis' Encyclical *Laudato si'*. Q. Rev. Biol. 91(3), 247-260. <https://doi.org/10.1086/688094>
- Rockström, J. et al. (2009). Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society, 14(2), 32. Last accessed on October 2, 2019, at <http://www.ecologyandsociety.org/vol14/iss2/art32/>
- Schimmel, A. (2001) Kleine Paradiese. Blumen und Gärten im Islam. Herder: Freiburg im Breisgau.
- Serag, M.S. (2003). Ecology and biomass production of *Cyperus papyrus* L. on the Nile bank at Damietta, Egypt. J. Med. Ecol., 4(3-4), 15-24. Last accessed on October 2, 2019, at <http://www.jmecology.com/wp-content/uploads/2014/03/03serag.pdf>
- Sezgin, F. (1967-2010). Geschichte des Arabischen Schrifttums (15 Vols.). Vol. 1 bis 9 (1967-1984): E.J. Brill, Leiden, Vol. 10-15 (2000-2010): Inst. History Arabic-Islamic Science, Frankfurt/M.
- Slotterdijk, P. (2006). Gottes Eifer. Vom Kampf der drei Monotheismen. Verlag der Weltreligionen, Suhrkamp/Insel: Berlin.
- Sperber, G. (1994). Bäume in der Bibel: Eine ökologische Un-Heilsgeschichte von Bäumen, Wald, Natur und deren Zerstörung und den gnadenlosen Folgen. Forstw. Cbl. 113, 12-34.
- Stückrath, K. (2012). Bibelgärten: Entstehung, Gestalt, Bedeutung, Funktion und interdisziplinäre Perspektiven. Vandhoeck & Ruprecht: Göttingen.
- Thyen, J.D. (2015). Bibel und Koran. Eine Synopse gemeinsamer Überlieferungen. Böhlau Verlag: Köln/Weimar/Wien.
- Weidner, S. (2018). Jenseits des Westens: Für ein neues kosmopolitisches Denken. Carl Hanser Verlag: München.
- Weizsäcker, E.U. von & A. Wijkman. (2017). Come On! Capitalism, Short-termism, Population and the Destruction of the Planet – A Report to the Club of Rome. Springer Nature: New York, NY.
- Von Rumohr, C.F. (2010). Geist der Kochkunst (Mit einem Vorwort von Wolfgang Koeppen). Suhrkamp/Insel: Berlin.
- White, L. (1967). The Historical Roots of our Ecology Crisis. Science 155(3767), 1203-1207. <https://doi.org/10.1126/science.155.3767.1203>
- Woenig, F. (1897). Die Pflanzen im alten Aegypten: Ihre Heimat, Geschichte, Kultur und ihre mannigfache Verwendung im sozialen Leben, in Kultus, Sitten, Gebräuchen, Medizin, Kunst. Verlag von Albert Heitz: Leipzig.
- Zohary, M. (1983). Plants of the Bible. Cambridge University Press: Cambridge.
- Zohary, M. & N. Feinbrun-Dotan (2005): Flora Palaestina (2nd ed.). Israel Academy of Sciences and Humanities: Jerusalem.

# FROM A SEA-SNAIL TO THE HEAVENLY THRONE: WILD FAUNA IN JEWISH LAW AND SPIRITUALITY

Y.M. BARILAN AND YEHOShUA WEISINGER\*

## Introduction

In the first part of this chapter, we reconstruct the rabbinic ethos on the relationship between humanity and the natural world. The Bible beholds the creation as good in its own right; but it also finds something deficient in humans as mere animal members of this holistic good. According to the Jewish sources, humans have a moral vision that sets them apart from the Darwinian struggle for survival. Attainment of that order might take millennia and may entail tolerance of human use of animals and other natural resources.

In the second part of this chapter, we discuss fundamental religious obligations that require familiarity with the natural world. One obligation is a memory aid – the purity of a natural color that reminds the person of religious law and of the beatific vision. Loss of one deep-sea species compromises this memory aid. The second obligation is a ritual necessary for the fulfillment of Jewish messianic future. The ritual depends on the preservation of a rare variant of domesticated animal. Intimacy with the natural world at large as well as with civilized nature are both necessary for the full realization of the Jewish religion.

## Humans and Nature

The first evaluative statement in the Bible refers to the goodness of nature. According to the Creator, the creation is “good”, even “very good”. Whereas humanist and utilitarian philosophies regard “goodness” in relation to somebody, usually a human or humans, the Bible posits the goodness of nature<sup>1</sup> as an independent good; goodness that is neither conditioned by

\* Bioethics and Law Center, Sackler Faculty of Medicine, Tel Aviv University, Israel.

<sup>1</sup> In the Hebrew sources, we find “creation”; nature is a Hellenic term. Both Greek (*physis*) and Latin (*natura*) refer etymologically to organisms that generate.

nor “tethered” to anybody.<sup>2</sup> It is a primary good. The Talmudic rabbis declare that even things that the tradition labels as “bad”, such as human “evil inclination” are good (Genesis Rabbah 9:9). In existentialist language, we may say that there is a unity in the background<sup>3</sup> of Being $\ddot{u}$ ; that it has an essentially concrete dimension, which is good, and this goodness is glowing in human consciousness. It might be presented as consciousness’s backlight. The fundamental affirmation of the goodness of creation comes with a significant theological price: if there is a unity of goodness in everything material, then the problem of theodicy is almost impossible to resolve. Recognition in the goodness of creation offers little practical guidance, because nature contains numerous and conflicting loci of interests. The good for one creature is the demise of the other; ecological stability never exists over significant periods of time, as climates shift, tectonic plates move and life on earth keeps altering the environment. Human normativity depends on *normative horizons* of symbolic order and purposefulness. Relative to such horizons it is possible to demarcate a normative matrix.

Whereas all plants and animals were created “on earth” and without any defined purpose, God took one creature and placed it in a circumscribed part of earth. This was man who was placed in the Garden of Eden “to dress and to keep” it. The Hebrew word in the text, **הַדְּבַעַל** is the very same expression used later in the Bible in relation to the worship of God – **דָּבַעַל** (Exodus 7:16). Throughout the Bible, moral human existence is *enclosed* within contexts of material and social culture. The book of Genesis regards “Men of the field” and hunters as wicked persons (Esau, Nimrod). Judaism has never extolled hunting as a noble pursuit; rather, even if licit by Jewish law, it has been considered “un-Jewish”.<sup>4</sup> Hence, since the dawn of Judaism, it has discouraged the practices that are responsible for the extinction of mega-fauna along with the ensuing ecological changes.<sup>5</sup>

<sup>2</sup> Utilitarian, Kantian and humanist philosophers tend to believe that every kind of good must be “good for somebody”. See Korsgaard (2018, 16-21).

<sup>3</sup> This refers specifically to Heidegger’s *stimmung*. It is a special kind of *stimmung* – affirmative and intentional.

<sup>4</sup> Barilan, Y.M. “The vision of vegetarianism and peace: Rabbi Kook and the ethical treatment of animals”. *History of The Human Sciences* 2004; 17:69-101.

<sup>5</sup> The role of early humans in Late Quaternary mass extinction is not fully clear. See Seddon, C. *Humans: From the Beginning*. 2nd ed. Glanville Publications, 2018; pp. 295-310. Perhaps the largest ecological impact of human expansion resulted from Western expansion, rather than by hunting. It was a unilateral ecological shift. Crosby, A.W. *Ecological Imperialism*. Cambridge: Cambridge University Press, 1986; p. 165.

The Biblical, historical and moral horizons do not stretch beyond the Neolithic period. The Bible knows only one genus of *homo*; domestication of species of animals and plants ceased and stabilized. Large settlements and empires are about to bud out. They constitute a human ecological context, which the Bible renders a kind of enclosure of physical safety and moral limits. The Biblical narratives of the Creation engulf the whole earth, from around 4000BCE as a unity that is good.

For the Jewish tradition, the challenge of environmental ethics hinges on the impact of civilized life on the larger environment. Whereas all forms of life expand within their ecological niches, the Bible sees human existence as circumscribed by abstract, non-natural enclosures, the first of which was designated by God himself. As the stories on the Fall and Cain illustrate, human life outside of the cultural enclosure is not freedom but banishment that is akin to death. Humans “dress the earth and till it” while living in *human* ecological niches, adapting to the environment while altering that environment. From the beginning, the Bible distinguishes between human and natural environment, which may include, for example, bees that pollinate fruit trees, and creation as such, completely unrelated to human life.

The circumscribed and goal-oriented human existence led to the second evaluative judgment in the Bible. Even though the creation of man was deemed “very good”, the Bible says, “And the Lord God said, ‘it is not good that man should be alone’” (Genesis 2:18). The resolution of this problem depends on Man’s subjective judgment. The affirmative recognition about human society is put in Man’s mouth, not God’s: “And Adam said, ‘this is now bone of my bone, flesh of my flesh’” (Genesis 2:22).

According to the Talmud (*Yevamot* 63a), Adam sought intimacy with every species of animal until he realized that his wholeness came from unity with another human. Hence, every human “family” (i.e. ethnic group) shares with this blessing. Humans are part of creation; yet, recognition in human “loneliness” and its resolution appears separate from the natural order. The interpersonal relationship between man and woman (and later between two humans) is of a different quality from the impersonal, even if intimate and caring relationships among animals. It is part of the cultural enclosure, setting human life apart from its mere animalistic properties. Humans share so much with animals – in their physiology, anatomy, mental life, even human spiritual experience roots deeply into non-human modes of being.<sup>6</sup> In full awareness of this all-embracing commonality, the Bible

<sup>6</sup> Abram, D. *Becoming Animal: An Earthly Cosmology*. New York: Vintage, 2010.



professes human culture as a radical break from animals' modes of survival and procreation.

Even though the Bible considers the creation good, and the Jewish tradition has never accepted gnostic and Manichean conceptions of the natural world,<sup>7</sup> Judaism has never affirmed that mankind is an integral part of nature. Humans need some assistance and independent human action in order to fulfil something that is beyond the biological survival of the human animal. Human presence involves an emergent moral perspective, principles and ideals that the rules of nature neither contain nor lead towards. The created man is "very good"; but it is not yet *good for man* to merely exist. Morality and religion appear in the gap between the background awareness of the creation as good, and humans search for the things that are *good for him or her*, most crucially, the kind of life that is worth living.

The Biblical moral vision extracts human behavior from the blind order of nature by projecting *transcendent ideals* and by extracting humans from the harshest pressures of survival. Humans will not be food to other animals; they will not have to compete with animals over natural resources.<sup>8</sup> The Bible tells a story about human struggle to live in nature, but not as part of nature; to live in harmony with nature, and yet, to be subjected neither to human natural desires nor to natural forces of predation. This double negation – do not act like a predator; you will not become a prey – is the essence of Genesis's morality. It is explicit in the Covenant with Noah. Even though it may happen that people prey on each other and that maladies, beasts and natural forces decimate human society, the Biblical point of view would never consider such events as normal, natural, as something we should accept. In the Biblical story, civilization begins within an enclosure – the Garden of Eden – where humans neither prey nor become predators. Following the Fall, humans are banished from their God-given enclosure. Wherever they go, humans must create cultural enclosures to protect and sustain them.

<sup>7</sup> Manichaeism posits a cosmology in which equally powerful forces of good and evil struggle. Early Christianity posited that even though the struggle was still raging, Jesus already tipped the balance in favor of the good. The Bible and the Talmudic literature do not offer a theology of cosmic clashes. Rather, for these sources, creation has been completed; humanity is comprised of one family; no independent significant opposition plays with nature against either God or the good.

<sup>8</sup> Barilan, Y.M. *Human Dignity, Human Rights and Responsibility: The New Language of Bioethics and Biolaw*. Cambridge (MA): MIT Press, 2012.

This is the idea of the “sanctity of human life” – humans shall not kill each other, nor should they accept non-natural death – the killing of humans by either animals or humans. The Talmudic rabbis explicate the reciprocity of this balance:

Why was man created last? If he lives virtuously and with the aid of the Holy Spirit – we tell him: you were created before the angels [who according to the Talmudic lore were created last]; if he fails, we tell him “a fly was created before you were” (Genesis Rabbah 8:1).

According to this Talmudic source, humans do not have a fixed place in the Great Chain of Being. Moreover, originally, people were not permitted to eat animals. God told the first humans that if humans comported themselves properly, animals would neither eat humans nor deprive humans of their essential resources. However, when people sin, animals rise and reign “above” them, prey on humans and on their vital resources (Rashi on Genesis 1:29).

The Talmudic literature explains in relation to the Laws of Moses:

“Every word of God is pure: he is a shield unto them that put their trust in him” (Proverbs 30:5). Does God care whether [a person] slaughters an animal from the neck (as Halakhah requires) or from the nape? No. The commandments were given in order to purify people” (Leviticus Rabbah 30:3).

The Rabbis convey a clear message, even in relation to the human relationship with animals. The fundamental concern of the Torah is the honing of human virtues, the cultivation of will power, the conquest of human “evil inclinations”. Rabbi Kook (1865–1935) explains that following the moral depravations of the prediluvians, God gave humans permission to eat animal flesh as to concentrate efforts on respect for human life. According to Kook, after the deluge, God downgraded the *value of life*, giving humans permission to eat animals, as to boost the *value of human life*, instilling better the taboo on homicide.<sup>9</sup>

According to Jewish mystical traditions, meat eating, even when licit (*Kasher*) stems from inappropriate desire, rooted in the Serpent. God wishes to direct humanity away from its material dimensions (today we may call them – Darwinian laws) towards non-predatory modes of life.<sup>10</sup>

In Judaism, the protection of human life and the cultivation of well-ordered society take precedence over the protection of the creation. Kook does not say that destruction of nature is a precondition for the realization

<sup>9</sup> Kook, A.O. “Afikim Ba-Negev” *Ha-Peles* 1903.

<sup>10</sup> b. Brechia of Modena, A., *Ma’avar Yaboq, Sefat Emmet*, ch. 16. (A 17th century book).

of human goals; rather, he says that coping with human's evil inclinations and tendencies to excess requires temporary leniency in relation to nature. Kook articulates a dialectic process. First, humans enjoy a non-predatory harmony within a protected enclosure; then human moral failures lead to harsh modes of life, in which exploitation and destruction of non-human life is instrumental to respect for human dignity; lastly, human cultures co-exist peacefully in nature.

Half a century after Rabbi Kook formulated this vision, human civilization realized that its liberties with nature reached a point in which humanity and the rest of creation share the same fate once again – human action threatens to annihilate life on earth. Human growth has expanded and unified cultural enclosures as to create a new epoch of globalization, the *Anthropocene*.<sup>11</sup> Only during the peaceful period following the Second World War, when life expectancy and health rose dramatically and lethal human violence plummeted to unprecedented low levels, did humanity begin to realize the price paid – the degradation of natural life and the risk of technological annihilation. Human freedom is about disentangling life from the constraints of necessity,<sup>12</sup> from disease, predation and oppression. Power relationships within human society rather than any primary relationship between humans and the creation seem to be the chief culprit.<sup>13</sup>

With the expansion of human civilizations, human enclosures have vanished. Humans do not need protection from “nature”; rather, it is “nature” that needs protection from human excesses. For the ancients, the Heavens stood for cosmic perfection and order. Alexander von Humboldt introduced the notion of global ecology, exploring “nature” as a dynamic web of inter-dependencies. He also pointed out that human action interferes with this natural order, often breaking it. He was the first to discuss the interaction between human enclosures and “nature”.<sup>14</sup>

### **The Blue Ribband and the Red Heifer**

The idea that Jewish religious duties are instruments to hone the virtues squares well with Hellenic philosophies as “ways of life”, regimens of restraint and virtue. These regimens are also meditative, cultivating a de-

<sup>11</sup> Lewish, S.L. and M.A. Maslin. *The Human Planet: How We Created The Anthropocene*. New Haven: Yale University Press. 2018.

<sup>12</sup> Arendt, A. *The Human Condition*. Chicago: University of Chicago Press, 1958; p. 120.

<sup>13</sup> Bookchin, M. “Social ecology versus deep ecology”. *Green Perspectives* 1987; 4-5:1-23.

<sup>14</sup> Wulf, A. *The Invention of Nature: Alexander von Humboldt's New World*. New York: Knopf. 2015.

tached and appreciative view of natural phenomena.<sup>15</sup> Some thinkers beheld the commandments (*mitzvot*), the Laws of Moses, as yokes necessary for taming human obstinacy and evil inclinations. However, the rabbinic tradition has developed a parallel imagery of the Jewish way of life. In this world of idioms, God's special love to His people is manifested in special, *interpersonal* relationships, within which, the religious duties are "benefits" (תּוֹרוֹת) bestowed by God, like jewels gifted by a lover to his beloved one and by a father to his beloved son. They are tokens of tenderness and loyalty, a kind of a secret sign language shared by two lovers.

"Set me as thy seal upon thine heart; as a seal upon thine arm: for love is strong as death..." (Song of Solomon 8:1).

In association with this "seal", the Talmud discusses the "signet and bracelet", which Tamar took from Juda as a token of personal recognition (Genesis 38:18 – in the Hebrew bible it is the same word *hotham* for what KJV translates as "seal" in Song of Solomon and "signet" in Genesis). According to the Talmud, the "signet" is the "blue ribband" mentioned in the book of Numbers:

Speak unto the children of Israel, and bid them that they make them fringes in the borders of their garments throughout their generations, and that they put upon the fringe of the borders a ribband of blue: And it shall be unto you for a fringe, that ye may look upon it, and remember all the commandments of the Lord, and do them; and that ye seek not after your own heart and your own eyes, after which ye use to go a whoring (Numbers 15:38-39).

This commandment touches fundamental issues of religious life. It serves as a *material memory aid* that is enmeshed in quotidian life (a cloth). It invokes the remembrance and awareness of *all the commandments*. The text also mentions the two key motivations behind the commandments – self-discipline by means of obedience (ye seek not after your own heart...) and, as the Talmud renders clearly, the idiosyncratic tokens of love between God and Israel. When lovers are distant and at risk of forgetting their mutual commitments, the token of love keeps the sparks of yearning burning. As Tamar hints to Judah, it registers promise and loyalty.

<sup>15</sup> Hadot, P. *Philosophy as way of life*. Oxford: Blackwell, 1995; pp. 189-190. The Talmudic sources describe how incidental viewing of the ribband can overcome the otherwise irresistible temptation of perfect sexual beauty and worldly riches. (Horowitz, H.S. (ed). *Siphre d'be Rab*. Lipaciae: Gustav Fock. 1926, p. 129). This detached perspective, which also values the goodness of creation, is the locus in which neither Judaism nor Christianity is reducible to either psycho-spiritual satisfaction or ethics.

Use of daily objects as memory aids is common in simple societies and religious traditions. The “fringes on the border of garments” – knots of some extra thread are a simple method for creating unique, and easily made symbols. But, the *tzitzit*, the fringe, contains a special element in addition to the simple white threads.

According to the rabbinic law, the blue ribband must come from one specific marine creature. The word employed by the oldest surviving source is snail תולדה (Tosefta Menahot 9). The Vulgate uses the Latin *hyacinthinas*, which means violet or blue.

The blue ribband is an excursion beyond the enclosure of culture, beyond the entire lifeworld. The Talmud says that the blue evokes the color of the sky which is the color of God’s throne:

“The *tekhelet* looks like the sea, and the sea looks like herbs, and herbs like heaven and heaven like God’s throne” (Talmud *Hulin* 89a).

Before we discuss this chain of associations, it is worth pointing out that the blue of the ribband is a visitor from a non-human realm, from nature that is uncivilized and beyond the scope of cultural enclosures. It comes from a creature of the deep seas. It is not cultivated, and it has no use beyond this symbolic coloring. Yet, a certain knowledge of marine biology is essential for the preservation of a tradition and for the realization of full religious life. The creature and the technology existed at the times of Moses and they are still within human reach today. The religious law on the ribband acts out the unity of creation from the chalcolithic period all the way through meaningful human future. The dispersal of the Jewish people and the destruction of its homeland by warfare brought about cultural losses – we do not know how to find the snail and we do not know how to process it as a dye. Human harm to the environment might drive the creature into extinction, and within it the promise of Jewish religious revival, which apparently depends on the preservation of an unidentified species of the deep seas. Moreover, the blue ribband comes as a memory aid for *all of the other commandments*. The memory aid does not invoke the Torah or the Covenant, but it is encyclopedic. It also reminds people of something they have never seen – God’s throne.<sup>16</sup> This ultimate image is neither cultural nor natural. It reminds one of the *visio beatifica* and its relationship to Grace that envelops creation and permeates its every atom.

The mnemonic effect of the blue ribband takes a tortuous and strange route. It begins in the sight of the unique blue of one marine animal pro-

<sup>16</sup> Yet, a deep cultural memory is invoked – see Exodus 24:10.

cessed by human art. This special color evokes herbs and sky – ubiquitous natural objects which are familiar to every human. Why cannot people look at the herbs and sky directly? Apparently, seeing herbs with mindfulness and knowledge of natural phenomena is more powerful psychologically and spiritually. Looking at herbs, we think whether it is good *for us*, we see it as a raw material, a substance to be removed or transformed. Seeing it from the broader perspective of the deep seas, detached from human desires and needs, bring forth its goodness as such. According to Heidegger, technology is a mode of discovering or exposing (*alètheuein*) reality as a raw material to be worked on and transformed.<sup>17</sup> When technology develops as a means to an end – as a good *for somebody* (usually human ends) we fail to discover the detached goodness of the creation.

The *tekhelet* is one of the three chief coloring pigments used in the Tabernacle (Exodus 25:2, 39:1). All three were extracted from invertebrate creatures which are of no other use for humans. The tradition about the production of *tekhelet* was lost. Some of the Talmudic sources are more legendary than descriptive. The post Talmudic literature is already disconnected from the relevant material culture. Some medieval rabbis use the word “fish” (Maimonides) and others “worm” (Rashi). The elaborate industry of dyes in Palestine disappeared in late antiquity. Medieval rabbis express different opinions regarding its color. According to Maimonides, it is black; according to Rashi – green. We know that the pigment was expensive (Talmud *Menahot* 44a). Perhaps, this is because the snail was quite rare, a creature that surfaces from the fathoms of the sea once in seven or even seventy years (Talmud *Menahot* 44a; *Masekhet Tzitzit*).<sup>18</sup>

Not only did Jewish law require that the *tekhelet* come from one specific snail, the coloring must also endure as well. “It must retain its beauty, without change” (Maimonides, *Hilkhot Tzitzit* 2:1-2).

The voluntarist and positivist dimensions of rabbinic law tie spirituality to the fabric of reality. The fringe must contain a specific kind of coloring. It must come from a specific animal and it must be processed by a specific technology. Jewish law accepts neither substitutes nor sublimations. Following the loss of the traditions about the natural source and industrial

<sup>17</sup> Heidegger, M. *The Question Concerning Technology and Other Essays*. New York: Harper, 1977; p. 12. Other aspects of Heidegger’s view of technology are quite remote from the discussion herein.

<sup>18</sup> It might be possible that the pigment was a common part of the garment industry of the Mediterranean. However, this article is about the Talmudic rendition and the rabbinic attempt to reconstruct the dye according to that tradition.

processing of the pigment, observant Jews omit this commandment from their lives. They wear the *tzitzit* without the blue ribband (Talmud *Mena-hot* 38b). Symbolically, it is possible to behold this loss relative to Adam's naming of all creatures. Jewish theology teaches us that alienation from the creation results in a compromised religious way of life and a compromised remembrance of the whole of the commandments. The extinction of species, loss of familiarity and oblivion of material culture bring a key token of love and fidelity between God and his people to annihilation.

The Biblical paragraph on the fringes and the ribbands appears in the most important part of the Jewish daily prayers. The Talmud explains that this paragraph contains five key elements of faith (Berakhot 12b). Hence, Jewish prayer invokes the memory of the fringe and ribbands; and the fringe and ribband invoke something that transcends culture and immediate human reality. It is noteworthy that according to an authoritative medieval rabbi, there is a special religious duty to *look* at the fringes and ribband, no matter how powerful meditation on prayer might be.<sup>19</sup> Judaism spins a string of memory aids and associations – the prayer recites the paragraph on the ribband, which is about the creation of a color that invokes the Heavenly throne. The paragraph also reminds every person of the Exodus and of the whole of the commandments. Alas, in the absence of the real color, this verbal string of associations falls short of the positive requirement and spiritual experience.

A similar loss occurred in relation to the “red heifer”, whose ashes are necessary for the performance of the ritual of purification from the impurity of the dead (Numbers 19). Whereas the blue ribband depends on familiarity with the natural world outside of human habitat, the disappearance of the red heifer is about erosion of biological diversity within human habitat, within the realm of domesticated and tamed life, within cultural enclosures. The heifer must be wholesome in its color. Hence, both ribband and heifer are about the *beauty of pure natural forms*. The wild sea snail needs industrial processing; the domesticated heifer needs not.

The redness of the heifer is not a mere sign but the essence of the ritual. Both ribband and heifer are about the beauty in color (Rashi on Numbers 19:3). The Talmudic rabbis took the commandment of the “red heifer” as emblematic of a King's decree that needs no explanation. According to one Talmudic source, when Moses rose to Heaven he found God deliberating

<sup>19</sup> Rabbi Isaac of Corbeill. *Sefer Mitzvot*, Mark 28.

the laws of the red heifer (*Psikta Rabbati, Parah*, mark 13). Hence, the verbal deliberation of the laws of the heifer stand for the *visio beatifica*.

Whereas the “red heifer” does not exist anymore,<sup>20</sup> the rabbis have always felt that the blue ribband requires *identification* of a creature still extant.

In the late 19th century, a Hassidic rabbi embarked on a philological scientific investigation in search of the lost snail. It was evident to the rabbis, that recovery of this lost tradition depends on the natural sciences and in people’s capacity to know the natural order and to preserve it. In a book published in 1887, Rabbi Henich Leitner (1839–1890) claimed it was the common cuttlefish. Thirty years later, Rabbi Isaac HaLevi Herzog (1899–1959) argued in favor of the *Murex Trunculus*. Although the vast majority of rabbis have not accepted these identifications as satisfactorily convincing, nobody contested the rabbi’s methodology, namely that the search for the snail requires scientific inquiry.<sup>21</sup> Rather, the rise of modern biology and chemistry brought the rabbinic community to think that reconstruction of the lost identification was becoming possible. A leading scientific inspiration was the extensive work of the Venetian pharmacist Bartolomeo Bizio on the chemistry of the ancient organic dyes.<sup>22</sup> Indeed, the Talmud endorses meticulous scientific observations as the means to understanding rabbinic law (*Sanhedrin* 5b).

In Judaism, we find many laws and practices that are related to the material life of a community – a society of agriculture at the edge of the Mediterranean. People and cultures think and experience the world through direct and repeated experience of their natural environment. In this phenomenal world, the sun rises, the earth is firmly set under feet and the sky is a canopy stretching up above the clouds. Merleau-Ponty writes:

*All my experience in the world, even my scientific knowledge, is gained from my own particular point of view, or from some experience of the world with-*

<sup>20</sup> Occasionally, there are reports of such calves being born and rabbis checking them for the required purity of color. There are attempts to breed such a cow with the aid of genetic engineering. The Jewish community of Ethiopia used a red heifer well into the twentieth century.

<sup>21</sup> Some rabbis insisted on a cultural inquiry “[issues in religious law] that are factual, are known by oral transmission, not by applying Talmudic criteria to the facts”. Soloveitchik, J.D. *Beit Ha’Levi*. Part IV, 2006; Mark 38. In the 1990s, The Chief Rabbinate of Israel was undecided about the appropriate methodology. Shpira A., *Mickrai Kodesh*, Jerusalem, 2018, p. 672.

<sup>22</sup> Ghiretti, F. “Bartolomeo Bizio and the rediscovery of Tyrian purple”. *Experientia* 1994; 50:802–807.



*out which the symbols of science would be meaningless. The whole world of science is built upon the world as directly experienced.*<sup>23</sup>

In a similar manner, Jewish spiritual life is anchored in and expressed by a universe centered in Jerusalem, whose daily activities are social life of cattle herding, farming and small industry of Biblical and Talmudic times. This was “the flesh of the world”<sup>24</sup> of Jewish culture, whose preservation and maintenance were key to the continuation of traditional society. This aspect of nature was anthropocentric, but not a dominating brand of anthropocentrism. It is not a desire-based or need-based view of the world. It is a way Jewish culture experiences, thinks and expresses itself through its material environment and natural horizons. As anthropologist Claude Levi-Strauss observes, “natural species are chosen [for cultural symbolism and ritual] not because ‘they are good to eat’, but because ‘they are good to think’”.<sup>25</sup> The cognitive process does not rise above nature but develops through intimate relatedness to natural phenomena. This cognition crafts an ontology “from within” the lived body. In Jewish law, the snail is not the symbol. It is the source of a pure form-less abstraction of color that distinguishes the blue ribband from the fringes and the red heifer from other calves. This pure color, though, must originate in a wild animal, and be processed by specific technology as to induce the desired spiritual experience.

We do not know whether the numerous biblical and Talmudic laws regulating agriculture serve ecological or economic purposes. We do know that they constitute a holistic communal way of life, a prism through which traditional Jewry beholds its life-world. This is what Hanna Arendt describes in relation to the Roman conception of “nature”. It is the immediate envelope of society. The seashores near town, the wild animals on its margins as well as the soil cultivated within.<sup>26</sup> Indeed, agriculture is historically and symbolically linked to labor, property and power relationship, the use of animals and social stratifications by matrices of gender, ethnicity and wealth.<sup>27</sup> People have weaved natural objects in their symbolic world order. Tamed nature, combined with architecture and artifice make elaborate memory aids and “meditation engines”.<sup>28</sup>

<sup>23</sup> Merleau-Ponty, M. *Phenomenology of Perception*. London, 1962, p. 8.

<sup>24</sup> Merleau-Ponty, M. *The Visible and the Invisible*. Evanston: Northwestern University Press, 1968, pp.83–84.

<sup>25</sup> Levi-Strauss, C. *Totemism*. Boston: Beacon, 1962, p. 89.

<sup>26</sup> Arendt, H. *Between Past and Future*, New York: Penguin Books, 1961, p. 48.

<sup>27</sup> Arendt, H. *The Human Condition*, Chicago: University of Chicago Press, 1958.

<sup>28</sup> Caruthers, M. *The Craft of Thought: Mediation, Rhetoric and the Making of Images, 400-1200*. Cambridge: Cambridge University Press, 1998, pp. 269–276.

The fringes on the border of garments embody such practices; some rabbinic commandments are irrevocably attached to very specific natural phenomena. The loss of the red heifer reminds us of the enormous diversity of cultured seeds and species that is under threat of extinction, no less than wild flora and fauna.<sup>29</sup>

Decimation and extinction of species and forms of life undermines Jewish religious life at its very core, where human cognition, human spirituality and the material world meet. Nowhere have the rabbis said that Jewish law was meant to protect the natural world. However, acquaintance with nature and its preservation are essential for the maintenance of the fabric of awareness from which Jewish religious life is weaved.

<sup>29</sup> Searbrook, J. "Sowing for apocalypse". *The New Yorker*, Aug. 27th, 2007.

MIKKEL WOLD\*

*How did we become trapped in the present crisis? What mindset brought us there and what are the main goals in order to restore a lost respect for nature. What is our hope?*

Like the nuclear threat, the climate crisis has such severe consequences that it is almost unbearable.

When things are unbearable, we tend to ignore and neglect them at first sight. This is one of the reasons why we sometimes see a tendency of denial, a repression of reality or worse, a tendency towards nihilism.

This is a well-known and well-described phenomenon in psychology, supported by numerous studies that demonstrate this tendency. A combination of denial and ignorance of reality has always been more popular than warnings about a coming but not very visible danger.

The psychologist and director of the Center for Green Growth at the Business School in Oslo, Per Espen Stoknes recently mentioned, referring to opinion polls in 39 different countries dating back from 1989, that the more we know about global warming, the more we tend to deny or reject that knowledge.<sup>1</sup>

Moreover, the aspect of our modern narcissistic culture is important for our understanding of our situation. In his book *Strategies for Survival*, psychologist professor Peter Elsass included a chapter titled “The New Type of Human Being: The Survival Artist” in which he points out that some of the modern critique of our society claims that our narcissistic culture has become a culture of survival – “defining ourselves as being among the last survivors – as victims, that is, who are still alive in spite of our civilization’s dissolution” due to a weakened egostructure, “which no longer can resist and contain the plurality, disunity and the ultimate sense, unintelligibility,

\* Pastor at Frederics Church, “Marmorkirken”, Copenhagen. Associate professor at the Centre for Pastoral Education and Research.

<sup>1</sup> Nyvold, M. (August 3, 2017). Hvorfor din hjerne er programmeret til at fortrænge denne klimahistorie, og hvad du kan gøre ved det [Why your brain is programmed to neglect this story about the climate and what you could do about it]. Last accessed on October 9, 2019, from *Zetland* at <https://www.zetland.dk/historie/sOMVE-ZWB-aOMNamWw-8ebe3>

of our surroundings”. Referring to Kohut and Lasch, Elsass continues to explain that scholars of the culture of narcissism often see acts of “selective apathy, emotional distancing, disregard for the past and future, [...] on the basis of a decision to live one day at a time, here and now”.<sup>2</sup>

For some, denial is their only alternative to despair. Thus, if there is no hope within sight, it is quite understandable that some people choose to ignore the problem. Denial is for some people a strategy for survival. Even for those trapped in a narcissistic culture. That is why we must never forget to speak about hope.

Another aspect is that we have seen a remarkable lack of insight and very little readiness to grasp consequences of the scientific results presented to us due to a tendency of overestimated belief in the future and a reluctance towards warnings about great but not generally visible dangers. People who formulate such warnings are regarded as pessimists by nature, and little attention is paid to their arguments. Just think of warnings issued by numerous scientists since the 1970s about the threats to our climate. These threats are still not the overall number one priority in the political debates, at least not in my country, one of the richest and so-called happiest countries in the world. And the private companies have until recently been very reluctant towards taking initiatives in favour of the climate. Although many CEOs are beginning to understand the severe consequences of not changing our behaviour, one of the conclusions from a series of workshops held in the spring of 2019 was that many CEOs still find the Sustainable Development Goals too “fluffy” to integrate in their business. Moreover, they found it difficult to see how these goals could contribute to the profit of their company!

Four years ago, the parliament in Denmark cancelled a special low tax on electric cars with the immediate result that the sale of these cars decreased dramatically. Even though the tax has been lowered a bit since 2015, the sale never recovered; the share of electric and hybrid engine cars sold in Denmark was merely 3% in the first three months of 2019.

We still suffer from the attitude, that dramatically pessimistic predictions are regarded as sensationalistic and naïve. But naivety can take many forms. In 1911, Norman Angell published *The Great Illusion*, which became a best-seller of that time. Angell’s primary thesis was that the economic cost of war was so great that no one could possibly hope to gain by starting a war with

<sup>2</sup> Elsass, P. 1995. *Strategies for Survival: The Psychology of Cultural Resilience in Ethnic Minorities*. New York/London: NYU Press, p. 182.

such disastrous consequences. For that reason, Angell's book was understood – I am not sure it was his intention – as the promotion of the argument that a general European war was very unlikely to start, and if it did, it would not last long. Even in 1913, this was a popular and widespread 'truth'.<sup>3</sup>

It is of decisive importance that we inform about the consequences and the (man-made) causes of the climate change and loss of species while, at the same time, expressing well-founded and realistic hope such that people feel heard and recognized and that science, religion, and knowledge could unite in the struggle for ensuring the most vital elements of life that are essential for all of us.

Recognizing the mental roads that led us to this uncivilized way of exploiting nature that we have practiced for so many years now is a part of the solution and our hope for the future.

The shameless view on nature

The understanding of and view on nature in the Western culture could best be described – as done by the Danish theologians professor K.E. Løgstrup (1905–81) and especially by his student professor Ole Jensen (b. 1937) – as not only stupid but also *shameless*.<sup>4</sup> We could add the words of the Chinese statesman Yen Fu, who shortly after World War I said, that we have a form of civilization that “has lost the ability of shame”.<sup>5</sup>

We have developed an ignorant and one-sided mentality of exploitation towards nature. The statistics from the International Union for the Conservation of Nature (IUCN) Red List of Ecosystems show this clearly. Published in 2008, this IUCN Red List “confirmed an extinction crisis, with almost one in four [mammals] at risk of disappearing forever. [...] The [...] study shows [that] at least 1,141 of the 5,487 mammals on Earth are known to be threatened with extinction”.<sup>6</sup>

<sup>3</sup> As argued by Florian Illies (2014) in his book *1913: Der Sommer der Jahrhunderts*. Frankfurt am Main: Fischer.

<sup>4</sup> Jensen, O. 2011. *På kant med klodens klima – om behovet for et ændret natursyn* [On edge with the climate of the globe]. Forlaget Anis: Copenhagen, p. 17; Løgstrup, K.E. 1984. *Ophav og omgivelser: Betragtninger over historie og natur: Metafysik III* [Origin and surroundings: Considerations of history and nature: Metaphysics III]. Copenhagen: Gyldendal, p. 54.

<sup>5</sup> Yen Fu according to Jensen, O. 1976. *I vækstens vold: økologi og religion* [In the grip of growth: Ecology and religion]. Copenhagen: Gyldendal, p. 51.

<sup>6</sup> IUCN 2008. IUCN Red List reveals world's mammals in crisis. Last accessed on October 10, 2019, at IUCN <https://www.iucn.org/content/iucn-red-list-reveals-world%E2%80%99s-mammals-crisis>

For the Red List of 2015, the IUCN assessed the extinction risk of more than 77,300 species and found 4,894 to be “critically endangered”, 7,322 to be “endangered”, and 11,028 to be “vulnerable” to become extinct. Breaking down these figures per species, identified 41% of amphibians, 33% of reef-building corals, 34% of conifers, 25% of mammals, and 13% of birds to be threatened with extinction.<sup>7</sup> The severity of these numbers becomes even more obvious and alarming when looking at the most recent numbers released in 2019. These identified a total of 28,338 species to be critically endangered, endangered or vulnerable which implies an increase of about 22% over the course of four years.<sup>8</sup>

Who gave us this license to kill? With what right do we act so scandalously? What mindset brought us to such a mentality? Have we been so deceived by our skills, our victories in science and technology that we have forgotten that nature did not start with humankind and that we deeply depend on nature? To quote Løgstrup: “We live in an immense and fantastic forgetting about what has been given to us”.<sup>9</sup> The important things in our lives cannot be possessed, they are at our disposal as gifts. This basic and simple observation is often forgotten.

How come that we think we possess and own nature? One angle leading to an understanding of the mindset that brought us to where we are is a remarkable proclamation by René Descartes (1596–1650). In 1637, he proclaimed that with the insight and knowledge of nature, “we would be able to make ourselves masters over and owners of nature” (“Nous nous pourrions rendre comme maîtres et possesseurs de la nature”).<sup>10</sup> Descartes would probably never have accepted the level of stupid exploitation that we see today; he was unable to foresee what lay ahead. However, what came was a combination of the thoughts expressed by Descartes and a dualistic approach in which nature was seen as something at humankind’s dis-

<sup>7</sup> IUCN 2015. The IUCN Red List of Threatened Species. Gland: IUCN. Last accessed on October 10, 2019, at IUCN [https://www.iucn.org/sites/dev/files/import/downloads/iucn\\_brochure\\_low\\_res.pdf](https://www.iucn.org/sites/dev/files/import/downloads/iucn_brochure_low_res.pdf)

<sup>8</sup> IUCN 2019. Table 2 – Changes in numbers of species in the threatened categories (CR, EN, VU) from 1996 to 2019. Last accessed on October 10, 2019, at IUCN [https://nc.iucnredlist.org/redlist/content/attachment\\_files/2019\\_2\\_RL\\_Table\\_2.pdf](https://nc.iucnredlist.org/redlist/content/attachment_files/2019_2_RL_Table_2.pdf)

<sup>9</sup> Løgstrup, K.E. 1978. *Skabelse og tilintetgørelse. Religionsfilosofiske betragtninger. Metafysik IV* [Creation and annihilation: Religious philosophical considerations: Metaphysics IV]. Copenhagen: Gyldendal, p. 141.

<sup>10</sup> Jensen, O. 2011. *På kant med klodens klima – om behovet for et ændret natursyn* [On edge with the climate of the globe]. Copenhagen: Forlaget Anis, p. 15.

posal. And from there man decided to abolish not only God, but the very phenomenon of something being sacred and holy. Man took the divinity away from God and placed rationality at the divine place instead. From that point onwards, nature was at man's brutal disposal and no longer admired as God's unique creation.

It was quite appropriate then – although I doubt that the disappearance of the sacred was what they had in mind – when geologists not so many years ago started to discuss whether we should have a new era, a new geological epoch, named the Anthropocene, having started – as some suggest – with the first nuclear test in 1945. The abandoning of the uniqueness of nature is symbolized by the first manifestation of the man-made ability to destroy the planet.

So what has the master and owner of nature achieved? Not ownership over nature. Nature is disappearing and will not listen to or obey the person who thinks he owns it. And losing the sense of sacredness, man has also lost his sense of spirituality. The rational *homo oeconomicus* has taken over.

“But aren't you forgetting spirituality?” some would say. Truly, spirituality has become a modern phenomenon, almost a buzzword. 151 million hits appear if you type “spirituality” into Google.

But what is spirituality today? Is it linked to the wisdom of those religions, from which it was once grown? Or has it been separated from its context and subjected to the rationality that today expresses itself in the shape of an instrumental attitude even to spiritual matters? I think the latter applies. And I think that is why modern spirituality cannot fill the gap and cry for meaning that has developed as a result of the loss of the sense of the sacred, the loss of musicality, and a deeper spirituality that we fail to experience nowadays.

We have replaced wisdom with knowledge, and even knowledge is being driven away in favour of information. Though we have never been as informed about facts as we are today, this information is not making us wiser.

### **Keeping tradition as a basis for renewal**

How come that we had such a loss in our understanding of wisdom and spirit?

In order to understand this, we have to realize the importance of a vivid tradition. If we lose tradition, we lose the source of civilization, the orientation and meaning given to us through the historical knowledge. “People become rootless if they forsake their heritage from the past”, said the former Keeper of National Antiquities in Denmark, P.V. Glob. It was a wise

thing to say and therefore it is written on the wall (sic) in the city-museum of the Danish town Fredericia.

Tradition is not to be confused with traditionalism. Traditionalism has to do with nostalgia in the sense of sentimentality for the past. As if you wanted to become what you once were. Awareness of tradition is the opposite of traditionalism.

It is a bit like the difference between love for your country and nationalism. Nationalism is the perverted version of love for your country as often seen in modern nationalism. At the moment, we experience a dangerous combination of nationalism and nostalgia. It carries the roots of totalitarianism and chaos.

In his book *Das Ende der Normalität*, Gabor Steingart, then editor of *Handelsblatt*, gives an account of what effect it has on society if it loses its orientation. The ignoring and forgetting of the values that shaped the society lead to a society in which there is no guideline or belief, no direction from man towards something else, nothing to live or die for. “Wer an nicht glaubt, verzweifelt an sich selber” (he who doesn’t believe in anything, will despair in his own self), Steingart writes quoting Goethe, who wrote these words in 1774.<sup>11</sup>

Remember also the wise former diplomat and resistance fighter Stéphane Hessel, who in 2010 wrote the famous essay *Indignez-Vous!* (Time for Outrage!),<sup>12</sup> originally printed in 6,000 copies, sold worldwide with more than 3.5 million copies. In both this essay and in his book *Engagez-Vous!* (Get Involved!)<sup>13</sup> from 2011, Hessel expresses his shock over the dismantling of the values and initiatives that were vital for the rebuilding of welfare in Europe.

The loss of values or rather the *loss of a vivid tradition carrying the narratives that teach us about life*, is a loss that will lead us into what the Austrian psychiatrist and Holocaust survivor Viktor Frankl called the “existential vacuum” and the loss of meaning in life. Frankl himself pointed out, that loss of tradition was the primary reason for the loss of orientation.<sup>14</sup>

<sup>11</sup> Steingart, G. 2011. *Das Ende der Normalität: Nachruf auf unser Leben, wie es bisher war*. Tübingen: Piper, p. 173.

<sup>12</sup> Hessel, S. 2011. *Time for Outrage!*. London: Quartet Books.

<sup>13</sup> Hessel, S. 2011. *Engagiert Euch!* [Get engaged!, trans. M. Kogon]. Berlin: Ullstein.

<sup>14</sup> Frankl, V. E. 2006. *Man’s search for meaning: The classic tribute to hope from the Holocaust* (transl. I. Lasch). Boston: Beacon Press.



## Relativism and nihilism today

Not only the loss of orientation but also *relativism* and, as a consequence thereof, *nihilism* are an important and very influential part of a modern mindset. It is of vital importance to understand this if we are to comprehend one of the greatest threats to hope and meaning.

A relativistic approach to truth, where – in short – truth ‘is what you make it’, is not uncommon. “What is true for you doesn’t have to be true for me”, a famous saying goes in Danish. It is considered an expression of tolerance but, in fact, it is an attitude of laziness towards truth itself. If everything is a social construct, then who is to say what is false or what is sick?

These relativist and nihilist tendencies are an inseparable part of the post-modern mentality. In the end, they make it possible to openly display an attitude that does not really care about truth. Those who practice politics with a total nihilistic attitude can reach the highest positions and offices. Such an approach has been in charge for many years, long before Trump & co. It has been an element in the discipline of political spin for many years. It is all about presenting a certain image; the relation between image and identity, though, is ignored, such that credibility is no longer of interest!

Those in favour of this attitude would probably claim that they just have a realistic (that is, a cynical), view on politics, and that people without this attitude are naïve and idealistic fools. But if they read their history, then they might learn from Immanuel Kant, who wrote “a lie always harms another; if not some other human being, then it nevertheless does harm to humanity in general, inasmuch as it vitiates the very source of right [*Rechtsquelle*]”.<sup>15</sup>

A relativistic concept of truth bears the source of cynicism and nihilism. A nihilism that comes out of the despair that grows from the belief that nothing matters. It is therefore of great importance to realize that some statements are true and some are simply not true. Our relation to truth is that it exists independently of us. I am not the creator of what I see. I am directed towards something that exists independently of myself. Otherwise, everything is just a product of my dreams and longings.

“But the seen depends on the eye that sees”, many would argue. Yes, that is true, but the *existence* of the seen is there and would still be there even if you – the viewer – were not. Existentially that is not only a great

<sup>15</sup> Kant, I. 1993. *Grounding for the Metaphysics of Morals: On a Supposed Right to Lie because of Philanthropic Concerns* (transl. J.W. Ellington; 3rd edition). Indianapolis/Cambridge: Hackett Publishing Company, 64–65.

relief, it is also part of the definition of existence. To exist means to be oriented outwards, towards something or somebody other than yourself. This is why we become ourselves when we forget ourselves. An “I” become and “I” only when it is oriented towards a “You” as pointed out by the philosophers Martin Buber<sup>16</sup> and Ferdinand Ebner.<sup>17</sup> To become oneself is to forget oneself in the occupation with somebody or something.

Thus, truth is not a product of our opinions. Instead, it exists independently of those searching for truth. For Kierkegaard this was essential. “Subjectivity is truth”, he said repeatedly in *Philosophical Fragments*.<sup>18</sup> Kierkegaard tried to attack the Hegelian speculative rationalism that neglected the subjective element and explained how it is in the passion that the problem of truth has its life:

*When the question about truth is asked objectively, truth is reflected upon objectively as an object to which the knower relates himself. What is reflected upon is not the relation but that what he relates himself to is the truth, the true. If only that to which he relates himself is the truth, the true, then the subject is in the truth. When the question about truth is asked subjectively, the individual’s relation is reflected upon subjectively. If only the how of this relation is in truth, the individual is in truth, even if he in this way were to relate himself to untruth.*<sup>19</sup>

However, when Kierkegaard says, “subjectivity is truth”, this should never be interpreted as if truth were subjective! In his writings, he warned (with a German expression) against what he called “übergreifende Subjektivität” – “all-embracing subjectivity” – in which case truth would change in the course of history depending on people’s concept of truth. Then ‘truths’ would be replaced by new ‘truths’. However, “the essentially Christian [in Danish: “det kristelige” – that is the Christian religion per se, my remark] exists before any Christian [in Danish: “kristen” – person, my remark]) exists. [...] even if no one had become aware that God had revealed himself in human form in Christ, he still had revealed himself”.<sup>20</sup>

<sup>16</sup> Buber, M. 1997. *Ich und Du*. Gerlingen:Verlag Lambert Schneider.

<sup>17</sup> Ebner, F. 1963. *Fragmente, Aufsätze, Aphorismen: Zu einer Pneumatologie des Wortes*. München: Kösel Verlag.

<sup>18</sup> Kierkegaard, S. 1992. *Concluding Unscientific Postscript to Philosophical Fragments* (Vol. I, ed. & transl. H.V. Hong & E.H. Hong). Princeton, NJ: Princeton University Press.

<sup>19</sup> Kierkegaard, S. 1992. *Concluding Unscientific Postscript to Philosophical Fragments* (Vol. I, ed. & transl. H.V. Hong & E.H. Hong). Princeton, NJ: Princeton University Press, 199.

<sup>20</sup> Kierkegaard, S. 2008. *The Book on Adler* (ed. Robert L. Perkins). Macon, Georgia: Mercer University Press, 117-118.

Why is this so important? Because if truth is something that in the end is just a part of the human creation, a product made by our ideas, we are not oriented towards something that exists independently of ourselves. This assumption goes along with an existential loneliness leading to the despair and nihilism that unfortunately is an influential factor in our time. It makes people disillusioned about the fundamental striving for truth and justice. This nihilistic attitude is often combined with a reductionism that tries to “explain” religion and spirituality as manifestations of the self and nothing more. It involves an anthropology, an understanding of man, that ignores man’s longing for a spiritual dimension, for meaning and for living for something more than just a short-sighted satisfaction of instincts. If everything is to be understood under the relativistic concept of truth, nihilism is right in our backyard and a great hindrance for the crucial formulation of hope.

In her eloquent book *Zivilisiert den Kapitalismus*,<sup>21</sup> German intellectual Marion Gräfin Dönhoff quotes German philosopher Hans Jonas who illustrated our situation in his book on ethics in the time of technology as follows:

*Nun zittern wir in der Nacktheit eines Nihilismus, in der größte Macht sich mit größter Leere paart, größtes Können mit dem geringsten Wissen davon, wozu. Es ist die Frage, ob wir ohne die Wiederherstellung der Kategorie des Heiligen, die am gründlichsten durch die wissenschaftliche Aufklärung zerstört wurde, eine Ethik haben können, die die extremen Kräfte zügeln kann, die wir heute besitzen. (We are trembling in the nakedness of a nihilism in which the greatest power mates with the greatest emptiness, the greatest ability with the smallest knowledge of: what for? The question remains whether without a restoration of the category of holiness, which was most thoroughly demolished through the scientific enlightenment, we can at all have ethics that can restrain the extreme powers we possess today).*<sup>22</sup>

It is obvious that the quotation is not to be understood as a general attack on the age of Enlightenment, but only on the worship of rationality. There are several examples of how the Enlightenment could combine a love for science, knowledge, and musicality in a way that would never isolate ratio from spirit.

<sup>21</sup> Dönhoff, Marion Gräfin von. 1997. *Zivilisiert den Kapitalismus: Grenzen der Freiheit*. Stuttgart: DVA, 14.

<sup>22</sup> Jonas, H. 2003. *Das Prinzip Verantwortung: Versuch einer Ethik für die technologische Zivilisation*. Ulm: Suhrkamp, 57.

Hopefully we are now on our way out of a culture of madness. Some may ask: Can a culture go mad? Or, more specifically: Can the mindset of a population change so dramatically that we, with some right, can describe it as more or less insane? Freud would definitely answer such a question affirmatively. He describes it thoroughly in *Civilization and Its Discontents*, where he speaks about a neurotic civilization and of a pathology of the civilized societies.<sup>23</sup> A society is able to develop an ever-deepening conflict with basic human needs. Our present culture has reached a point at which it is almost suicidal.

### Ways of hope

So what can we do?

Recognizing the spirit of Einstein, that “a problem cannot be solved by the thinking that created the problem”,<sup>24</sup> we need to look for new roads. We cannot continue on the roads we have been following so far.

However, we can put the discourse about hope on a sound foundation without ignoring reality. We need to know what we can do; it is not sufficient to talk about hope in general terms. Optimism without facing reality will be short-lived.

We can learn from the past and try to abandon some of the insanities of our culture that so unethically have tolerated the exploitation of nature. We can learn from the fact that renewal comes from remembering the treasures of the past and integrating them into the shaping of the future. We must speak up and use the tools given to us, especially from this place, the Pontifical Academy, which hosts some of the most inspiring meetings in which the future can be formed.

The world can be changed if we want it to be changed! We are not slaves of a man-made illusion of a necessity that sees growth and the market-ruled economy as the only tools in society. Greed is not good, but has ruled society for the last decades with predator-capitalism as its result. Striving for utility has occupied our mentality to a degree, that we have almost lost sense of the importance of matters other than money and security. As Fukuyama says in his latest book: “What one really needs is a theory

<sup>23</sup> Freud, S. 1953. *Civilization and Its Discontents*. London: Hogarth Press, p. 141 ff.

<sup>24</sup> Einstein actually wrote, “A new type of thinking is essential if mankind is to survive and move toward higher levels” in an article titled “Atomic Education Urged by Einstein”, published in the *New York Times* on May 25, 1946. However, the idiomatic adaptation is more frequently known.

of why some people pursue money and security, while others choose to die for a cause or to give time and money to help other people”.<sup>25</sup>

We also see a new generation looking for other ways and visions for a better world. Last year, a professor asked his students in climatology at the University of Copenhagen why they had chosen this topic as their course of study. The answer from all of them was: Because we want to make changes for a better world. Such an answer would not have been possible just a few years ago. Today, however, large parts of the young generation are pre-occupied with more than their own careers, and they are no longer afraid of being called do-gooders if they try to make the world a better place.

We, who happen to live in the privileged part of the world, must abandon some of our wealth, in order to create support for the countries in whose areas nature of vital importance for the entire planet is situated. If we want to prevent these countries from doing what we did in many Western countries at the end of the 19th and the beginning of the 20th century – that is, from turning forests into agricultural landscape – then we must work together with these countries to ensure that they do not end up paying the bill that we have an ethical obligation to share.

We should not try to turn the world into a paradise, but we can use all our strength to find ways of making the world more humane, giving people the possibility to live there lives so that we share the richness and the resources in a world given to us in a way that could never be possessed or owned by us.

One of the most hope-giving publications recently is the encyclical *Laudato si'*. Even in the protestant country I come from, this great publication has been an inspiration to many who normally would pay absolutely no attention to what any church had to say. Reaching out to people is possible. If we combine reality, hope, and love, we have a good chance of changing the world.

“May our struggles and our concern for this planet never take away the joy of our hope”.<sup>26</sup>

<sup>25</sup> Fukuyama, Francis. 2018. *Identity: The demand for dignity and the politics of resentment*. New York, NY: Farrar, Straus and Giroux, p. 13.

<sup>26</sup> Pope Francis. 2015. *Encyclical letter Laudato si' of the Holy Father Francis on care for our common home*. Vatican City: Vatican Press, # 244. Last accessed on September 26, 2019, at [http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco\\_20150524\\_enciclica-laudato-si\\_en.pdf](http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si_en.pdf)

## ► List of Participants

**Vanderlei S. Bagnato**  
PAS Academician

**Wilhelm Barthlott**  
Prof. em., Nees-Institute for  
Biodiversity of Plants, University  
of Bonn, Germany

**Philippa J. Benson**  
Managing Editor, Science Advances,  
Washington, DC, USA

**Lori Bettison-Varga**  
President & Director, Natural History  
Museum of Los Angeles County,  
USA

**Joachim von Braun**  
President of the Pontifical Academy  
of Sciences

**John R. Clark**  
Chair of the Center for Plant  
Conservation, San Diego, California,  
USA

**Sarah Darwin Vogel**  
Botanist, Berlin, Germany

**Bruno David**  
President, Muséum National  
d'Histoire Naturelle, Paris, France

**Hailemariam Desalegn Boshe**  
Former Prime Minister of Ethiopia  
and Chair of Hailemariam & Roman  
Foundation

**María Clara Domínguez Vernaza**  
Cali Zoological Foundation,  
Colombia

**Alberto Gómez Mejía**  
President of Colombian Botanical  
Garden Network, Colombia

**Anthony N. Hitchcock**  
Kirstenbosch National Botanical  
Gardens, SANBI, South Africa

**Thomas Kauffels**  
Director, Opel-Zoo, Kronberg,  
Germany, and Chairman, European  
Association of Zoos and Aquaria  
(EAZA), UK

**Marco Lambertini**  
Director General, WWF

**Richard W. Lariviere**  
President, The Field Museum,  
Chicago, Illinois, USA

**Theo B. Pagel**  
Zoo Director and CEO of Cologne  
Zoo, Germany

**Mark Pilgrim**  
Vice-Chair EAZA and Chester Zoo  
CEO, UK

**Peter H. Raven**  
PAS Academician

**Marcelo Sánchez Sorondo**

Bishop Chancellor of the Pontifical  
Academy of Sciences

**Paul Smith**

Secretary General of Botanic Gardens  
Conservation International, London,  
UK

**Gloria Svampa Garibaldi**

President, Italian Association of  
Zoos and Aquaria, Zoological  
Director of the Education & Nature  
Conservation Departments of the  
City Museum of Zoology of Rome,  
Italy

**Virgílio Viana**

Director General of Sustainable  
Amazon Foundation (FAS), Manaus,  
Brazil

**Johannes C. Vogel**

Director of Natural History Museum,  
Berlin, Germany

**Sergey Volis**

Kunming Institute of Botany, CAS,  
China

**Christina Walters**

Seed storage, USDA-ARS National  
Laboratory for Genetic Resources  
Preservation, USA

**Yehoshua Weisinger**

“Bioethics and Law Initiative”,  
Sackler Faculty of Medicine, Tel Aviv  
University; Schlesinger Institute for  
Medical-Halachic Research, Shaare  
Zedek Hospital, Jerusalem, Israel

**Mikkel Wold**

Lutheran Parish Priest at  
Marmorkirken, Copenhagen,  
Denmark