OASIS EARTH

Planet in Peril

Our Last Best Chance to Save Our World

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ABOUT CIRQUE PRESS

Cirque Press grew out of *Cirque*, a literary journal established in 2009 by Michael Burwell, as a vehicle for the publication of writers and artists of the North Pacific Rim. This region is broadly defined as reaching north from Oregon to the Yukon Territory, and south from Alaska to Hawaii, and west to the Russian Far East. Sandra Kleven joined *Cirque* in 2012 working as a partner with Burwell.

Our contributors are widely published in an array of journals. Their writing is significant. It is personal. It is strong. It draws on these regions in ways that add to the culture of places. We felt that the works of individual writers could be lost if they were to remain scattered across the literary landscape. Therefore, we established a press to collect these writing efforts. Cirque Press seeks to gather the work of our contributors into book-form where it can be experienced coherently as statement, observation, and artistry.

Sandra Kleven – Michael Burwell, publishers and editors

Cover: "NASA Blue Marble 2007 West," a fusion of art and science using imagery from several satellite missions overlaying data on land surfaces, polar sea ice, and phytoplankton chlorophyll in the oceans. NASA intends the image to "inspire people to appreciate the beauty of our Home Planet and to learn about the Earth system," NASA/Goddard

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DEDICATION

In honor of the 50th anniversary of Earth Day (April 2020) and World Environment Day (June 2020), *Oasis Earth* is dedicated to our extraordinary living Home Planet - for nurturing and sustaining the evolution of life over billions of years; for being patient with *H. sapiens* while we learn to control our destructive impulses; and for the remarkable resilience that will restore Earth in the coming Ecocene, with or without us.

ACKNOWLEDGMENTS

A huge thanks to all those who helped bring this book to publication, especially Marybeth Holleman, an exceptional thinker, writer, editor, and naturalist (and due to a rare lapse in her judgment years ago, my wife). As well, thanks to the many photographers around the world who contributed their evocative photographs to this effort, including those from the U.N. Environment Program/Canon Inc. International Photographic Competitions for the Environment, NASA, Greenpeace, Unsplash, Pexels, Pixabay, Johnny Johnson Photography, and Carhenge.

Special thanks to the thousands of dedicated scientists around the world who continue to document our planetary biosphere and its decline, and their contributions to studies cited in *Oasis Earth.* Notably, the most often cited sources in the book are the U.N. Environment Program (UNEP), Lester Brown (Worldwatch), and Professor E.O. Wilson (E.O. Wilson Biodiversity Foundation). Thanks as well to the many astronauts who have looked upon our lovely little blue and white planet from space, offering their insightful comments.

As well, thanks to the thousands of people across the world who continue to push for the urgent policies necessary to secure a sustainable future – artists, poets, politicians, filmmakers, journalists, musicians, activists, corporate officials, Indigenous Peoples, provocateurs all.

Praise for *Oasis Earth*

Oasis Earth is a remarkable summary of the miracle that is life on the earth. At the same time, it describes how our ignorance is violating this phenomenal mystery in every possible way. It clearly instructs us as to who and what we need to become if we are to reverse our collective madness and become the true denizens we once were and can become again.

Paul Hawken, Author of *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*

I have been diving and exploring the oceans for over 74 years, ever since my father pushed me overboard with a tank on my back. It's been my privilege to share with the next generation, including my son and daughter Fabien and Celine, the fact that all plants and animals, including us, are connected and depend upon one water system, as detailed in *Oasis Earth*. It's why I want everyone to know, if you protect the ocean you protect yourself.

Jean-Michel Cousteau, President of Ocean Futures Society Inc.

Rick Steiner's *Oasis Earth* is a book of great importance at this moment in human and planetary history. We are at a crossroads and one way or another, dramatic changes are coming. Humanity can no longer pursue a path of endless population and economic growth, violence and destruction of nature and unchecked carbon emissions without suffering devastating consequences, both to ourselves and the millions of species with whom we share this planet, our only home. The author is an inspired teacher and his lesson is one that desperately needs to be heard. From ecological decline to war and conflict; from wealth inequality to the widely felt malaise with modern life, Steiner understands the importance of recognizing the many converging crises that we must confront. Fortunately, we still have time to choose the future we all want and Steiner shows clearly what is needed to move from the destruction and excess of the Anthropocene to the resilience and stability of the 'Ecocene'. We can do so much better and Steiner shows us how. Read this book. Be alarmed. Then take action.

Mark Brooks, WWF-Canada

The window of opportunity is closing. What we do, or fail to do, in the next decade will determine the fate of life on Earth and human civilization. *Oasis Earth* illuminates the way forward with the light of beauty, reason and hope.

Kierán Suckling, Executive Director, Center for Biological Diversity

Professor Steiner presents a stark and confronting picture of the way in which modern life takes the resilience and bounty of our precious planet for granted. Born of a deep love for the earth and its people's, the solutions offered here are *no-brainers*. Decision-makers, community leaders, citizens – please pay heed and act – in time.

Dr. Helen Rosenbaum, Deep Sea Mining Campaign, Australia

This publication should nudge even the most hardhearted to wake up to the reality that we live in very precarious times. Professor Steiner's deep concern for ecological justice and a conviction that urgent actions can help preserve what is left of the species that Nature has birthed is evident on every page — in photographs and in words. This is a cry of Nature for humans to see that the harm inflicted on other species, our relatives, is unconscionable and must stop. And, this is not merely about preserving exotic species, it is about the future of humankind.

Nnimmo Bassey, Director, Health of Mother Earth Foundation,
Nigeria, Former Chair, Friends of the Earth International

Our very lives are in a critical state because of what we are doing to the Earth. Air pollution causes 2.3 million human deaths each year. Water pollution causes 5 million human deaths each year. Some 40% of soil is seriously degraded due to industrial agriculture. If we keep on this path, soil for growing food could be wiped out in 60 years. About 90% of all big fish are gone from our oceans and seafood could be wiped out in 40 years. Roughly 40% of all living species are at risk of extinction due to human activities. We have only 10 years to stabilize the climate change damage we have already done. We do not have the luxury to waste time contemplating further destructive industrial activities that serve to enrich a few while future generations and species are left to suffer the irreversible consequences. It is both immoral and a serious human rights violation. This book serves to inspire the growing worldwide movement of humans concerned and disturbed by the rate of man-made destruction; may it act as a guide and inspiration to find lasting change.

Swakopmund Matters, Namibia

It's all here. Everything we need to know about our privileged and precious space on Earth and what we must do to restore it.

Spencer B. Beebe, Salmon Nation; Founder, Ecotrust
Founding President, Conservation International
Former President, The Nature Conservancy International

On the precipice of self-inflicted climate catastrophe, scientist Rick Steiner presents an unflinching exposé of the causes and consequences of ecological decline that already pose an existential threat to humanity`s most vulnerable. The solutions Steiner offers are visionary, and hopeful, as they illuminate the transformative opportunities before us to protect the planet while creating a more just and equitable society. Steiner`s love of our earth and of humanity motivates this book; its vivid writing and stunning images must motivate us all to make the necessary changes.

Dr. Catherine Coumans, MiningWatch Canada

For more than 30 years, Bellona has fought for practical solutions to environmental problems. The challenges are many and complex, but if humans are ingenious enough to bring about so much havoc, we believe they also can and will prevail in solving them, given we do not waste more time. *Oasis Earth* is part of the mass engagement needed to show that humankind has no alternative but to save the environment – ultimately, to save ourselves.

The Bellona Foundation, St. Petersburg and Murmansk, Russia; Oslo, Norway; Brussels, Belgium

Steiner captures the magnificent accident of Earth's evolution and the many interrelated stresses humans impose on it. An insightful, positive and motivating agenda for the change the Earth needs.

Charles Roche, Executive Director, Mineral Policy Institute, Australia

The book is a fiery call to save the planet. The appeal is based on a deep understanding of the material and spiritual aspects of the global environmental crisis and on faith in triumph of the human mind.

Sergey Kuratov, Ecological Society Green Salvation, Kazakhstan

As a child, I grew up in Siberia on the banks of a huge free-flowing river, endlessly carrying cubic kilometers of clear water past my small village. Today this river is shallow and slowly dies, blocked by dams and poisoned by industrial effluent. The water from this river that I drank during my childhood, can no longer be drunk without extensive purification. And now I understand how great a privilege it is to simply draw clean water from the river with a mug and drink it. Pure water, clean food and clean air have become a luxury - do we really want them to disappear completely? Of course not. But we continue to follow the path of destruction of all that provides our existence, our well-being, our life. Our global environmental crisis is the main challenge of the 21st century, and we have to act on this before it is too late. We cannot take away the right to drink clean water from the river from current and future generations.

We were able to tame fire, animals and plants, master metals and oil, create written language, build cities and power plants, split atoms, land on the Moon, defeat hundreds of deadly diseases, decipher the genome, and connect billions of computers and smartphones into a single network. But at the same time we continue to destroy our planet. As we destroy the Home where we live, we cannot yet be considered a rational species. We have very little time left to act rationally in order to save our future, and *Oasis Earth* helps us understand this.

Dimity Lisitsyn, Sakhalin Environment Watch, Russia

On my desk is a sealed jar of crude oil from the *Exxon Valdez*. It was collected by Professor Rick Steiner of the University of Alaska from under beach stones on Latouche Island, Prince William Sound, on 2nd March 1999 almost 10 years after the infamous Alaskan oil spill.

Professor Steiner is no longer with the University of Alaska. His work to reveal the cause of the *Exxon Valdez* grounding, to expose the inadequate and tardy compensation payments, to establish citizens' oversight of the Valdez oil terminal and to warn against environmentally disastrous malpractice in the oil industry, infuriated the big oil companies that ultimately finance the university. They accused him of 'campaigning' (a thing they'd never do themselves, of course).

In the end they piled so much pressure on the craven university administration that Rick resigned from his tenured post and went freelance. He is now one of the most renowned and respected marine conservation experts in the world, known and valued far beyond his home state of Alaska.

Rick Steiner is an erudite, eloquent, impassioned man and it's no surprise that his new book, *Oasis Earth: Planet in Peril, Our Last Best Chance to Save Our World,* is a masterpiece. In merciless, concise and compelling prose he documents just why and how we're destroying our environment at an accelerating pace, and what we must do to keep the Earth habitable for our descendants.

This is the message he's been putting across in memorable seminars and presentations over the past 30 years, using spectacular images from some of the world's finest photographers. Many of these superb pictures appear in this timely and wonderful book.

Al Gore's warnings were persuasive; Rick Steiner's are conclusive; we really do have only about 10 years left to turn our spaceship around, or we're all headed for the rocks.

Dr. Jonathan Wills, Retired Environmental Journalist,
Wildlife Guide and Author, Bressay, Shetland Islands, Scotland

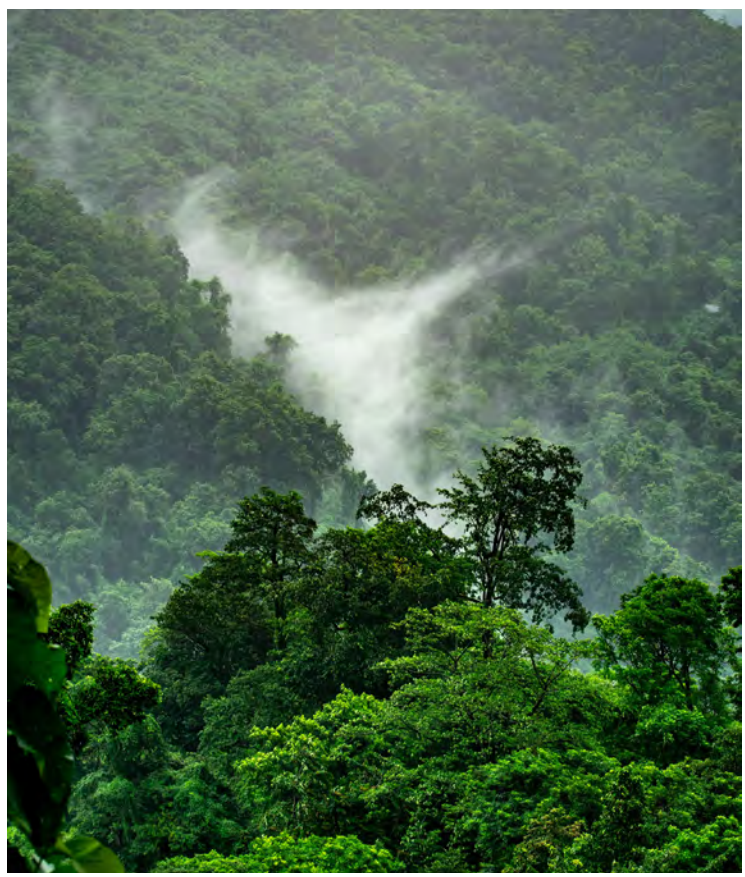
Oasis Earth is a must read for world leaders who pull the strings of our planet, and who need to understand how every part of the Earth is interconnected and functions as one global ecosystem. A great addition to fight widespread eco-illiteracy affecting the most well-intentioned men and women in power, killing the planet through their ignorance.

Sandra Kloff, Marine Conservation Expert, West Africa
Marine Eco-Region (Mauritania, Senegal, Gambia,
Guinea Bissau, Guinea and Sierra Leone)

Science confirms that humanity is currently destroying the biosphere of Earth, ourselves and our future with it.

We know the causes, the consequences, and the solutions to the crisis, but our efforts to date have not been enough to reverse global environmental collapse. On this crisis, we are out of time – almost.

This decade, 2020-2030, is our last best chance to secure a sustainable future.



The Earth from here is a grand Oasis in the vastness of space.

JIM LOVELL, APOLLO 8 ASTRONAUT, DURING FIRST MANNED LUNAR ORBIT, 1968[1]

Suddenly, from beyond the rim of the Moon, in long, slow-motion moments of immense majesty, there emerges a sparkling blue and white jewel, a light, delicate, sky-blue sphere laced with slowly swirling veils of white, rising gradually like a small pearl in a thick sea of black mystery. It takes more than a moment to fully realize this is Earth…home.

EDGAR MITCHELL, APOLLO 14 ASTRONAUT, ON SEEING EARTH RISE FROM THE LUNAR SURFACE, 1971[2]

A mote of dust suspended in a sunbeam…the only home we've ever known.

CARL SAGAN, ASTRONOMER, *PALE BLUE DOT*, 1994, COMMENTING ON THE MOST DISTANT PHOTOGRAPH EVER TAKEN OF EARTH, 4 BILLION MILES AWAY, BY THE VOYAGER 1 SPACECRAFT AS IT LEFT THE SOLAR SYSTEM FEB. 14, 1990[3]

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KNAUF

I

INTRODUCTION

A "grand oasis in the vastness of space…a sparkling blue and white jewel…the only home we've ever known." Orbiting the Sun in a continuous stream of its starlight, our exquisite little wet, warm, blue-green planet provides everything we need as we drift through the cold (-270°C/-455°F), dark, uninhabitable vacuum of space.

It is hard to imagine a more a sublimely perfect, habitable planet than Earth:

- Earth is of perfect size and density to hold a substantial gaseous atmosphere (most of it within 50 miles of the surface), and an electromagnetic field (extending thousands of miles above the surface, generated by the rotation of the molten outer core), both of which help shield the planet surface from harmful cosmic rays, charged particles of solar wind, gamma rays, X-rays, and ultraviolet radiation;
- The tilt of its rotational axis is an optimal 23.5° due to early Earth's impact with the planet Theia 4.5 billion years ago, giving rise to cyclical seasons and keeping the planet surface from reaching extreme temperatures;
- The axis tilt has remained relatively stable for billions of years, due largely to the stabilizing gravitational pull of our Moon;
- Earth and our solar system are in a relatively quiet region of space, encountering few catastrophic impacts from large extraterrestrial bodies such as comets and asteroids;
- Earth has a stable, optimal rotational period, preventing one side of the planet from becoming too hot and the other side too cold;
- Earth is of perfect density to exert optimal gravity for life forms to exist;
- The atmosphere admits visible light energy that is captured by the carbon-based chlorophyll molecule in plants and algae, forming the photosynthetic foundation of most (but not all) Earth ecosystems;
- The atmosphere has just the right concentration of oxygen (21%), produced by photosynthetic plants and

algae, enabling aerobic life to flourish, but not too much oxygen to combust;

- The planet orbits the Sun in the "Goldilocks Zone" (not too hot, not too cold), where a remarkable solvent - water - necessary for life can exist in a liquid phase; frozen water at the poles helps to maintain climatic stability, and water vapor flows throughout the lower atmosphere redistributing freshwater across the biosphere;
- Biogeochemical cycles provide efficient carbon and nutrient cycling, and microbial decomposition of organic matter supports chemistry necessary for life, purification of water and air, and regulation of pests and diseases;
- The planet supports millions of co-evolved, interdependent species inhabiting every possible niche in an ecologically stable, thin living membrane - the *biosphere* - enveloping a dynamic crust, mantle, and core.

We owe our entire existence and continued survival to these co-incident biophysical phenomena. And while there may be other habitable planets in our, or other, galaxies, the probability of humans ever reaching such distant planets is extremely remote. With today's space travel technology, it would take more than 70,000 years to reach even the closest exoplanet (outside our solar system), Proxima Centauri b, which may or may not be habitable. Long into the foreseeable future, Earth will be our one and only home.

As well, Earth's biosphere is also where we derive much of our sense of beauty, identity, curiosity, wonder, art, and emotional and spiritual wellbeing. The planetary biosphere is our life support system, and determines how we are who we are.

But science is also clear about another stunning conclusion:

Human activity is destroying the biosphere of our Home Planet, ourselves and our future with it.

This is arguably the most consequential discovery in the history of science, yet many continue to ignore this extraordinary conclusion. Industry continues profiting through environmental destruction; governments look the other way or feign concern without taking substantive action; and many continue unsustainable consumer behavior ignoring the dire consequences. The global environmental situation is far more dire and urgent than many government officials admit.

The current trajectory of global environmental decline points toward a rapidly approaching dystopian future for civilization and the biosphere. As we exceed planetary boundaries, the way humans live on the Earth will change, one way or the other, very soon. Either we will adapt our lifestyle to a sustainable biosphere, or we will not survive.

If present environmental trends continue, the planet will be virtually uninhabitable for humans and perhaps half of all other species by 2050, certainly by 2100. In fact, for many people and species, in many places, it already is. Some put the chances for humanity surviving to the end of this century at only 50%.[4]

The ecological footprint of humanity today is well beyond Earth's carrying capacity, and growing. Human activities (mostly just since 1950) have resulted in the

Some scientists put the chances of humanity surviving this century at 50/50.

loss of half the world's forests, wetlands, grasslands, and mangroves; loss of 15-30 million acres of forest each year; annual use of 75% more resources than Earth can sustain; use of 25% of the planet's daily land plant production and half of all available freshwater; loss of billions of tons of topsoil each year; spreading desertification; thousands of species extinctions each year; loss of more than half of the total number of all vertebrates and invertebrates; runaway climate change reaching catastrophic thresholds, rising sea level, acidic oceans, and melting ice caps, permafrost, and glaciers; water and air pollution in every corner of the world; and over 75% of the land surface of the Earth and 66% of the ocean converted or significantly impacted by the activities of just one species - *Homo sapiens*.

In addition, the socioeconomic condition of civilization is in decline, with world population projected to reach 11 billion by the end of the century; severe and growing economic inequality; over 700 million people now living in extreme poverty and hunger; millions of refugees displaced by environmental disaster; 16,000 children under the age of five dying each day due to preventable causes; 19,000 people dying each day from breathing polluted air; chronic food and water shortages; a billion people without basic sanitation and clean drinking water; more people enslaved than at any time in human history; many unstable fragile and failed states; thousands of nuclear weapons on hair-trigger alert; rising mental illness and extremism; and growing global insecurity.

Many nations euphemistically called "developing" are actually failing or failed states, and are unsustainable due to lack of resources; and many nations called "developed" are increasingly unstable. While attention and resources are diverted to rising global insecurity, conflict and terrorism, environmental collapse continues unabated.[5]

Although we often tend to focus on a single part of the problem – e.g., climate change, species extinction, habitat loss, agriculture, pollution, population, poverty, and security – in fact, all of these environmental and socioeconomic factors are interrelated, mutually reinforcing,

and synergistic. Even if we were to solve climate change today, the world would still be hurtling toward ecological catastrophe due to the many other cumulative drivers of environmental decline. Either we solve all of these problems together and soon, or it's essentially game over for civilization as we know it. Our evolutionary imperative is simple: evolve or die.

While the Chicxulub asteroid impact 65 million years ago caused the legendary Cretaceous mass extinction (including the dinosaurs), this time we *are* the asteroid; we are the apocalypse. Earth is dying, and we are the cause.

> *Since the 1970s, humanity has been in ecological overshoot, with annual demand on resources exceeding what Earth can regenerate each year. Today humanity uses the equivalent of 1.7 Earths to provide the resources we use and absorb our waste.*
>
> GLOBAL FOOTPRINT NETWORK, 2019[6]

The unprecedented planetary transformation and ecological decline caused by human activities prompted scientists to mark the end of the relatively stable, 12,000 year-long Holocene geological epoch, and the beginning of the "Anthropocene" – the human era.[7] Due to the current loss of species, evolutionary biologist E. O. Wilson goes further, labeling our time the "Eremocene" – the age of loneliness.[8] A recent U.N. global biodiversity assessment estimates that:

> *About 1 million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history.*
>
> U.N. INTERGOVERNMENTAL PANEL ON BIODIVERSITY AND ECOSYSTEM SERVICES (IPBES), 2019[9]

In fact, many scientists now believe the crisis to be far worse than this, with half of all species (perhaps 4-5 million) threatened with extinction by the end of this century due to human activities.[10] At the mid-range estimate of the rate of species lost today, the biosphere has already lost over one million species in the last 50 years.

As ecological decline has occurred over decades and broad spatial scales, rather than overnight and locally, it has been less perceptible to many. Our primate-minds evolved to fear immediate threats, such as predators, or freezing or starving to death; not chronic, multi-decadal, large-scale change. As such, many people now seem to accept our degraded ecological state as normal – a shifted baseline from which we measure and accept our current degraded condition. Many still don't recognize the crisis, even though we are all right in the middle of it.

The global environmental situation is far more dire and urgent than many officials admit.

The 1992 "World Scientists' Warning to Humanity," issued by the Union of Concerned Scientists, noted the "ever-increasing environmental degradation that threatens global life support systems on this planet," and called upon govern-

ment leaders to take immediate action to reverse these worrying trends.[11] The 1992 warning stated that:

> *A great change in our stewardship of the Earth and the life on it is required, if vast human misery is to be avoided.*
>
> WORLD SCIENTISTS' WARNING TO HUMANITY, 1992[12]

Unfortunately, 25 years later, the 2017 "World Scientists' Warning to Humanity: A Second Notice," issued by over 15,000 scientists from 184 countries, noted not only that this necessary "great change" in environmental stewardship had not occurred, but that most environmental trends have become "alarmingly" worse.[13] The 2017 "Second Notice" warns:

> *By failing to adequately limit population growth, reassess the role of an economy rooted in growth, reduce greenhouse gases, incentivize renewable energy, protect habitat, restore ecosystems, curb pollution, halt defaunation, and constrain invasive alien species, humanity is not taking the urgent steps needed to safeguard our imperiled biosphere…*
>
> *Soon it will be too late to shift course away from our failing trajectory, and time is running out.*
>
> WORLD SCIENTISTS' WARNING TO HUMANITY: A SECOND NOTICE, 2017[14]

The 2017 scientists' warning notes that, except for encouraging improvements in Earth's protective stratospheric ozone layer, all other environmental trends are now far worse than they were in 1992 – freshwater availability, unsustainable marine fisheries, ocean dead zones, forest loss, biodiversity loss, carbon emissions and climate change, human population, and ruminant livestock population levels.

The United Nations "Global Environment Outlook 6" (GEO 6) released in March 2019, agrees with these dire conclusions:

> *…the overall condition of the global environment has continued to deteriorate…despite environmental policy efforts across all countries and regions. Unsustainable human activities globally have degraded the Earth's ecosystems, endangering the ecological foundations of society. Urgent action at an unprecedented scale is necessary to arrest and reverse this situation, thereby protecting human and environmental health and maintaining the current and future integrity of global ecosystems.*
>
> U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[15]

Alarmingly, the U.N.'s GEO 6 concludes that for assessed socio-ecological systems – atmosphere, land, water, oceans, and biodiversity – environmental degradation now ranges from "serious to irreversible."[16]

And every year since 1947 the Bulletin of Atomic Scientists has set its "Doomsday Clock" in minutes-to-midnight (with midnight representing the end of civilization), to convey the urgency of the primary existential threats to humanity and the planet. The Nuclear Threat Initiative says that today's 14,000 nuclear

The ecological footprint of humanity today is 75% beyond Earth's sustainable carrying capacity.

weapons are "enough to destroy the planet hundreds of times over."[17] In 2007, the Bulletin of Atomic Scientists added climate change to the threat of nuclear annihilation as primary existential threats, and in early 2018, the Clock was moved forward to just 2 minutes to midnight (closer than at any time since 1953), after adding a new existential threat to its calculus:

> *In addition to the existential threats posed by nuclear weapons and climate change, new global realities emerged, as trusted sources of information came under attack, fake news was on the rise, and words were used in cavalier and often reckless ways.*
>
> BULLETIN OF ATOMIC SCIENTISTS, 2017[18]

Propaganda, misinformation, and our irrational propensity for self-delusion are now considered existential threats to civilization. Perhaps unique among animals, when humans don't like the reality they are presented, many simply fabricate another fictitious one. Each day during his first year in office, U.S. President Donald Trump made an average of 5.6 "misleading or simply false claims."[19] Subsequently, Mr. Trump's rate of public lying accelerated to 23 per day, and these lies were spread virally via social media.[20] Some people want to hear fairytales instead of the truth. Government lying has become epidemic around the world.

Considering the many additional existential threats we face - overpopulation, biodiversity loss, habitat loss, resource depletion, rise of fragile/failed states, and unintended consequences of technology - the overall threat is clearly even more severe and immediate than previously recognized.

A worrisome resurgence of right-wing, nationalistic populism around the world has swept anti-environment politicians into national leadership – in the U.S., Australia, India, Philippines, Israel, Russia, Brazil, Italy, E.U., and the U.K. This regressive political backlash has delayed and undermined urgent actions needed to transition to sustainability. Clearly, much of humanity remains resistant to the transformational change needed.

The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide.

SIR ROBERT WATSON, U.N. IPBES CHAIR, 2019[21]

Even among those who understand the severity of the environmental crisis, there can be a peculiar tendency to simply "inhabit the problem" without acting to solve it. Thousands of scientific conferences and publications, news articles, and media presentations continue to document global ecological decline, but many people continue to simply observe the problem rather than acting to solve it. There is a dangerous *paralysis by analysis* with environmental decline – paradoxically, it seems the more information we have confirming our decline, the more paralyzed we have become. On this issue, knowing without acting would be a fatal mistake.

We are the first generation to know that we are destroying our planet and the last one that can do anything about it.

TANYA STEELE, CHIEF EXECUTIVE, WWF-UK, 2018[22]

When we honestly measure our efforts to address the global environmental crisis against the alarming realities of today, it is time to admit that we are losing the fight, not winning. Despite thousands of people and organizations sounding the alarm for decades about the environmental crisis - scientists, activists, theologians, artists, writers, poets, musicians, politicians, businesses, religions – the headlong charge toward ecological catastrophe continues.

We are already locked into catastrophic changes, terrible human and animal suffering, the loss of so much of what makes this Earth itself.

ALISON KEIMOWITZ, PROFESSOR, 2018[23]

Our well-intentioned efforts since 1970 may have slowed ecological decline, but we have clearly not halted or reversed it. Earth's biosphere continues to unravel and is in an apocalyptic death spiral of our own making.

In the face of such complex problems, it is difficult to see where the capacity lies to address these challenges.

BULLETIN OF ATOMIC SCIENTISTS, 2012[24]

Our lifeboat is sinking. We know it, we know the causes, we know the consequences, and we know how to correct the problem, yet government and corporate leaders continue business-as-usual. The band plays on as our ship goes down.

Given the progressive destruction of our biosphere... people today are aware that the world, as they know it, may come to an end. I am convinced that this loss of certainty that there will be a future is the pivotal psychological reality of our time.

JOANNA MACY, ENVIRONMENTAL AUTHOR, 1990[25]

Clinical psychologists now refer to syndromes such as "solastalgia" (a combination of "solace" and "nostalgia"),

as the emotional distress caused by environmental loss; and "ecoanxiety" or "ecological grief" as depression, stress, grief, despair, and fear about environmental decline. Beyond this, there is a growing sense of collective shame that our species alone is responsible for this unprecedented ecological collapse. Ecopsychological angst has been called "the definitive disease of the 21st century."[26] But so far, psychologists have only described the malady, not the cure.

There are four principal ways people respond to this "pivotal psychological reality of our time" - global ecological collapse:

1. Denial: Using self-validating misinformation (such as is now epidemic in our political discourse), to deny the existence of the problem. Corporate interests that profit from environmental destruction continue to invest millions of dollars to foster public doubt about the seriousness of our environmental situation, seeking to preserve the destructive (yet to them, beneficial) status quo.

2. Indifference: Accepting the reality of environmental decline, but either not caring or reasoning that it won't affect them personally: e.g., it will affect other people in other places or at some time in the future. This category may also include the hundreds of millions of people living in extreme poverty who are understandably more focused on day-to-day survival than global environmental decline.

3. Fatalism/Nihilism: Accepting the science, but assuming we have already passed the ecological "point-of-no-return," and giving up hope (many scientists and conservationists privately confess this sentiment); also in this category are those who find the implications and solutions intractable and overwhelming.

4. Constructive engagement / Problem solving: Committing to do everything possible to redirect our current disastrous course before it's too late.

> *What beauty. I saw clouds and their light shadows on the distant dear Earth....The water looked like darkish, slightly gleaming spots....When I watched the horizon, I saw the abrupt, contrasting transition from the earth's light-colored surface to the absolutely black sky. I enjoyed the rich color spectrum of the earth. It is surrounded by a light blue aureole that gradually darkens, becoming turquoise, dark blue, violet, and finally coal black.*
>
> YURI GAGARIN, RUSSIAN COSMONAUT, ON FIRST HUMAN SPACEFLIGHT, 1961[27]

Given the robust body of science documenting this global decline, what's at stake, and the necessary and achievable solutions, denial, indifference, and fatalism are irrational responses. None of these constitute corrective action.

It is the conviction of *Oasis Earth* that the coming decade, 2020-2030, will see a break*down* or break*through* for humanity and life on Earth. Urgent, constructive engagement to solve the crisis, at the global scale necessary, is the only rational path forward. Science has done its part by identifying the crisis, its consequences, and its solutions. Now government, industry, and we-the-people need to act on that science and solve the crisis.

> *Nature does not negotiate.*
>
> U.N. SECRETARY GENERAL, ANTONIO GUTERRES, 2019[28]

Inevitably, the Anthropocene will evolve into a sustainable "Ecocene" era.[29] The current unsustainable trajectory of humanity will end, one way or the other, likely by the end of this century. Unsustainable means unsustainable. The Anthropocene mass extinction will run

If present environmental decline continues, the planet will be virtually uninhabitable for humans and at least half of all other species by 2050. For many people and species, in many places, it already is.

its course and be over within a century or two. The question though is how many species, including *Homo sapiens*, will survive into the sustainable Ecocene. If previous mass extinction events are predictive, it may take 5-10 million years for the biosphere to fully recover from the current Anthropocene extinction. The future biosphere will be significantly different than the past, but recover it will.

If humans want to be part of the future Ecocene, we know exactly what we need to do by 2030: We must reduce global carbon emissions by 50%; stabilize human population; halt destruction of ecological habitat; place half of the Earth's lands and waters in protected status; reduce extinction rates to pre-human background levels; shift to a zero-waste, circular economy focused on stability and equity rather than endless growth; shift to sustainable, low-impact agriculture; significantly reduce wealth disparity and poverty; provide education and heath care for all; dismantle all nuclear weapons; and transition from an Anthropocentric to an Ecocentric worldview.

Clearly, this will take a major transition in our current political culture. While such transformation may seem improbable, it is possible. Again, the Anthropocene-Ecocene transition will occur, with or without the survival of humanity.

The 2019 Scientists' Warning of a Climate Emergency concludes that:

> ***Despite 40 years of global climate negotiations, with few exceptions, we have generally conducted business as usual and are largely failing to address this predicament.***[30]

And lamenting the insufficiency of global efforts to combat climate change, the U.N. Secretary General's climate envoy recently conceded that the effort will require:

> ***...an exponential increase in ambition.***
>
> LOUIS ALFONSO DE ALBA, U.N. CLIMATE ENVOY, 2019[31]

The same is true of efforts needed to reverse all drivers of global environmental collapse.

We know the causes, the consequences, and the solutions to the crisis, but our efforts to date have not been enough to reverse environmental collapse. On this, we are out of time – almost.

The "Green New Deal" introduced in 2019 into the U.S. Congress calls for, by 2030, a 50% reduction in U.S. carbon emissions, 100% renewable energy, universal health care and basic income, and green jobs. While the proposed congressional resolution is general, aspirational, and would not directly change U.S. environmental laws, it hints at the scale and urgency of the government response needed to reverse environmental decline.

The coming decade will be the most critical existential moment in the history of our species - either we fix these interconnected environmental problems now, or we will not survive long into the future. It is just that simple, and just that perilous.

We are all privileged to be living at perhaps the single most challenging time in human history - we should appreciate this opportunity and responsibility, and rise to this challenge.

> ***Orbiting Earth in the spaceship, I saw how beautiful our planet is. People, let us preserve and increase this beauty, not destroy it.***
>
> YURI GAGARIN, RUSSIAN COSMONAUT, FIRST HUMAN TO ORBIT EARTH, 1961[32]

If humanity does survive into the Ecocene, we will have a stable, sustainable population; a stable, circular, equitable zero-waste economy; clean, renewable energy; a stable climate; expansive ecological protected areas; extinction rates at prehistoric background levels; and peace,

security and social stability. But if humanity wants to be part of this sustainable future, we desperately need a major paradigm shift by 2030. As many have observed: "There is no planet B."

> *I have a unique view of our planet. Up here I see its beauty, its fragility, and also the impact humans make. What's in your hands today is no less than the future of our world. It is crystal clear from up here that everything is finite on this little blue marble in a black space, and there is no planet B.*
>
> ALEXANDER GERST, EUROPEAN SPACE AGENCY ASTRONAUT, COMMENTING FROM THE INTERNATIONAL SPACE STATION TO THE U.N. COP24 CLIMATE CONFERENCE IN POLAND, DECEMBER 2018[33]

Five hundred years ago, inhabitants of Rapa Nui (Easter Island) in the southeast Pacific didn't recognize their self-imposed ecological decline until it was too late, and ecological collapse was soon followed by societal collapse. There must have been a point at which some on the island recognized their impending collapse and demanded change, while others denied this truth and argued to continue their unsustainable lifestyle. Today, we are at a similar stage in the history of global civilization. What then will be our fate?

> *We came all this way to explore the Moon, and the most important thing is that we discovered the Earth.*
>
> BILL ANDERS, APOLLO 8 (FIRST LUNAR ORBIT), 1968[34]

As our collective efforts over the past 50 years have failed to halt or reverse ecological decline, and we have at most 10 years left to redirect this disastrous trajectory, it is urgently necessary to try new approaches. As Albert Einstein cautioned: "We can't solve problems by using the same kind of thinking we used when we created them."[35]

Many politicians continue to ignore environmental decline, and we now must make it more a liability for policymakers to continue ignoring this crisis than to admit it and solve it. And on this, policy incrementalism is no longer sufficient – we need bold, transformative policy solutions immediately. This will be up to we-the-people.

The history of the possible end or survival of humanity is being written right now, right here, by us. It is hoped that *Oasis Earth* will contribute to the bold approaches needed to meet this historic existential challenge.

Oasis Earth is organized into three principal sections (note: the idea that an Earthly Paradise can be lost was articulated 350 years ago, by John Milton, 1667):

II. Paradise: Our Living Planet
III. Paradise Lost: Global Ecological Collapse
IV. Paradise Restored: Solutions for a Sustainable Future

The book summarizes and connects the beauty of life on Earth, our current ecological and social collapse, and solutions needed by 2030. The Conclusion itemizes specific goals in *Oasis Earth Agenda 2030.*

To provide unique perspectives on our precious living Home Planet, *Oasis Earth* includes quotes from some of the 563 humans ever to have viewed this "blue and white jewel" from space – the astronauts. ●

This decade is our last best chance to secure a sustainable future.

II

PARADISE:

Our living planet

Every hour of the light and dark is a miracle
Every cubic inch of space is a miracle.

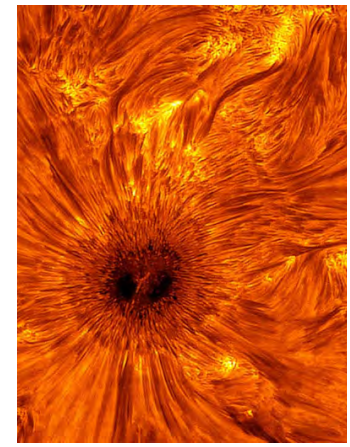
WALT WHITMAN, POET[36]

To fully appreciate what we are currently losing with Earth's environmental decline, we need to take stock of the exquisite biosphere we have and how it came to be. We often take our improbable evolution and existence for granted - the air we breathe, the water we drink, the food we eat, the animals and plants with whom we share the biosphere, and the sunlight that warms our planet in the cold dark vacuum of space. Perhaps we shouldn't.

The emergence of life in the cold, dark, vacuum of space is truly astonishing, and by all accounts, astronomically improbable. Whatever cosmology one lives by - Indigenous, Christian, Muslim, Judaic, Hindu, Buddhist, pantheist, animist, atheist, or science - it is clear that our very existence, and that of the myriad forms of life with whom we share the Home Planet, is truly "miraculous," not in a *supernatural* sense, but in a quintessentially *natural* sense.

By all odds life shouldn't even exist, but against all odds, here we are. If only one of the many coincidences at the basis of physical existence hadn't occurred when and as it did, we wouldn't be here to wonder about it all.

If we were to remind ourselves of this more often, it might be easier to celebrate existence, treat the Home Planet that sustains us with respect, and to motivate change in public policy toward protection of the biosphere of Earth. Toward that end, it seems appropriate to briefly recount the science of how we came to be - the most remarkable story ever told.



Improbable Universe

The cosmology of modern science holds that in the beginning, 13.8 billion years ago, all that we know of today as "universe" - what would become space, stars, galaxies, light, gravity, planets, mountains, oceans, and life - was bound together in a compressed state of pure potential far smaller than the period at the end of this sentence - the "singularity." According to relativity theory, because this singularity was so massive, time and space itself did not yet exist.

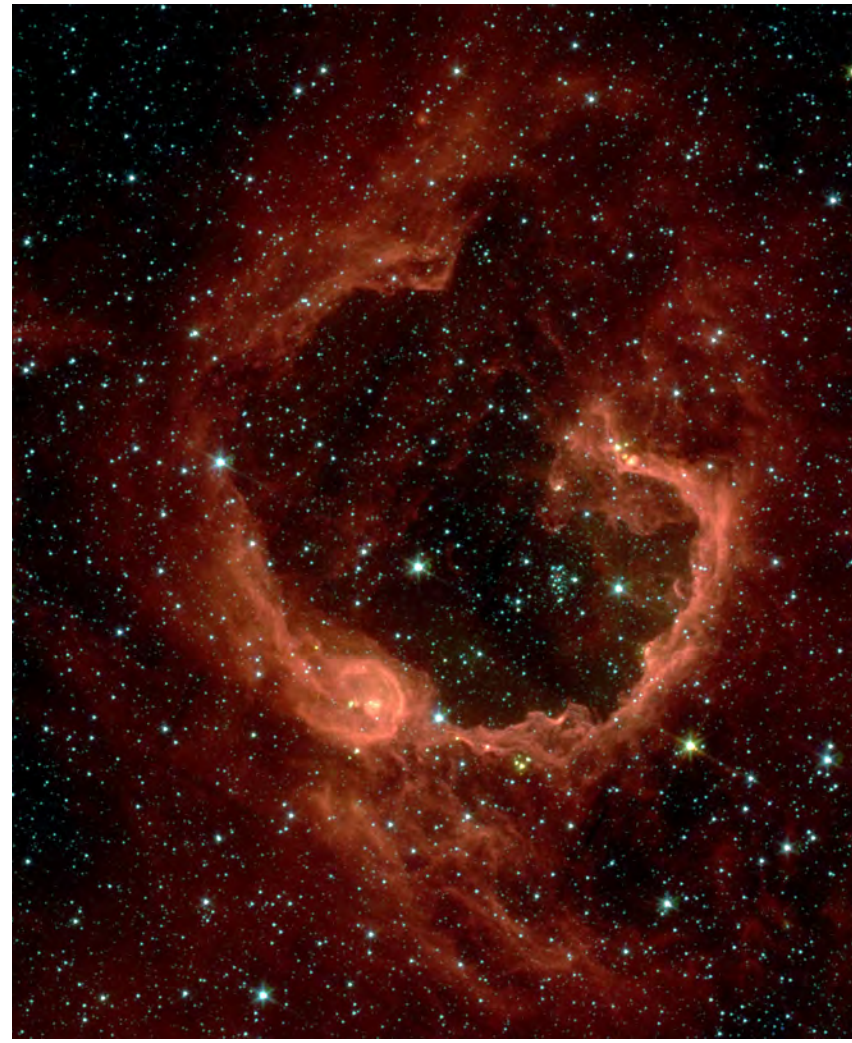
Then, for some unknown and perhaps unknowable reason, the singularity exploded in "the Big Bang." There seems to be agreement among cosmologists that within 10^{-33} of a second, the universe inflated in volume by an astonishing factor of 10^{78}. Subsequent to this extraordinary Cosmic Inflation, expansion slowed, but continues today, now at an accelerating rate.[37] There are alternative theories regarding this event, with some cosmologists theorizing that the singularity may have never existed.[38] Whatever occurred, it seems well beyond the imagination and comprehension by our small primate-minds.

In the conventional theory, the big bang occurred everywhere at once, giving rise to the very existence of space and time. As some have observed: "The Big Bang happened right where you're sitting just as much as anywhere."[39] Even today, all of space remains infused with the dim remnant afterglow of the big bang, the cosmic microwave background (CMB) radiation.

Some speculate that this explosion may have occurred several times before, but because the many physical events necessary for the formation of the universe were absent, each time had re-collapsed into the singularity – the "Big Crunch." Other theories suggest that universal inflation has been occurring for an infinite time, and many universes continue to form simultaneously as a "Multiverse."

The expansion continued, forming a universe that, by some estimates, is now over 92 billion light-years in diameter – called the "Hubble Volume." Others suggest the universe may now be over 7 trillion light-years across. And if, as some suggest, the edge of the Universe is expanding outward faster than the speed of light, the light from objects streaming outward at the edge will never reach Earth - a cosmological event horizon beyond which lies the largest part of the Universe, a world that will never be seen from Earth. It now seems likely that the Universe is far larger and more imponderable than what we will ever be able to observe or imagine.

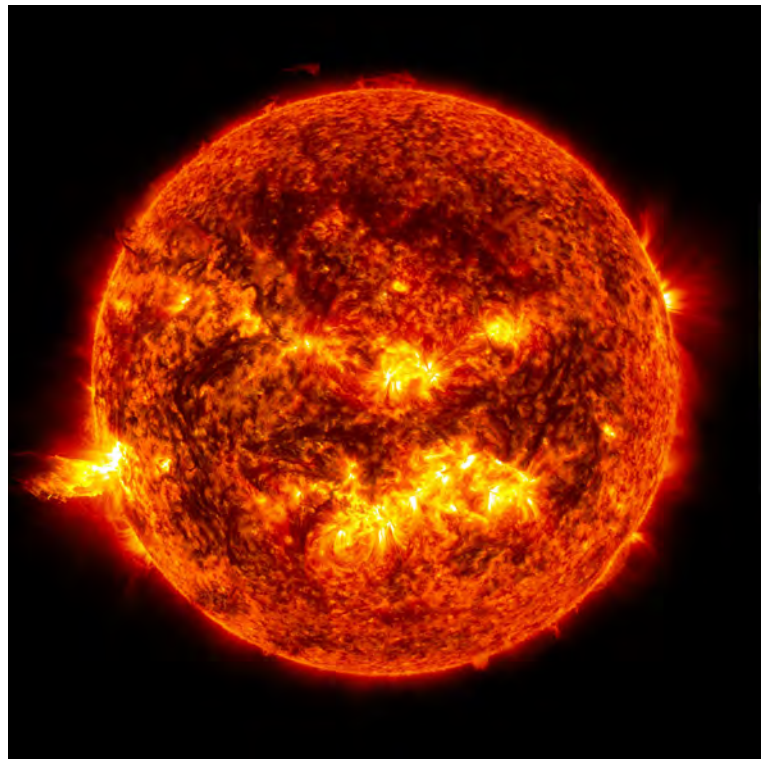
Regardless, it is evident that the Big Bang set forth such a synchronous coincidence of events that



evolved from pure energy to light, matter, structure, life, and eventually all the way to self-reflective consciousness that the Universe would eventually come to contemplate and even enjoy itself. Astronomer Fred Hoyle mused that it was no more probable that this would happen than "a wind blowing through a junkyard would form a Boeing 747."[40]

The unlikely chain of synchronous events necessary to produce the phenomenon of life and sentient thought and self-awareness from a remote explosion 13.8 billion years ago is simply staggering.[41] Some refer to this sequence of coincidence as the "Anthropic Principle" (although this title seems unnecessarily anthropocentric).

Some of the coincident precursors to life on Earth include the following:



- The explosion of the Big Bang had to be perfectly smooth and of uniform temperature so as not to collapse on itself;
- The rate of expansion had to be precise, within 1 millionth of 1 percent. Any slower and it would collapse, any faster and no matter could form;
- The charge of the proton and electron had to evolve to be exactly equal and opposite in order for matter to form;
- The neutron had to weigh just slightly more than the proton so that light could shine from stars;
- Forces of gravity and electromagnetism had to become delicately balanced in stars to prevent collapse;
- Symmetry of matter, speed of light, dimensionality of space, and elementary units of charge had to evolve precisely as they did;
- A specific nuclear resonance in Red Giant stars had to evolve in order to fuse hydrogen and helium into heavier elements necessary for life, such as carbon.[42]

Our Solar System formed approximately 4.6 billion years ago, from the gravitational collapse of a huge particulate cloud, forming the Sun at its center, with a protoplanetary disk of gas and dust extending outward. Earth formed shortly after, about 4.54 billion years ago, due to gravitational accretion of this gaseous disk.

In addition to the coincident precursors of the physical structure of the Universe, the many other coincident biophysical phenomena that make Earth a livable planet were required. These include: a size and density sufficient to maintain an atmosphere, one that is transparent to sunlight wavelengths necessary for photosynthesis; an electromagnetic field protecting the surface from cosmic radiation; infrequent impacts from large extraterrestrial bodies; optimal tilt of the rotational axis and rotational velocity to mitigate temperature extremes; the orbit around our star in the "Goldilocks Zone" where water can exist in liquid phase; evolution of the chlorophyll molecule that efficiently captures sunlight energy; biogeochemical cycling of nutrients and organic matter; and millions of interdependent species coexisting in the mutually supporting biosphere.

If only one of these symbiotic phenomena hadn't evolved exactly when and as it did, we would not be here to wonder about all of this. Rather humbling. Again, it is hard to imagine a more exquisitely habitable planet that our home, the Earth.

Ephemeral Earth

Earth has not always existed and will not exist forever. Our Home Planet, and the life on it, is exquisite, improbable, and ephemeral.

As the Sun continues to fuse hydrogen into helium in its core, it is slowly collapsing, increasing its rate of fusion, temperature and brightness.[43] This increases the Sun's brightness about 1% every 100 million years, a 30% increase in brightness over the Sun's 4.5 billion year lifetime.[44] Astronomers predict that a billion+ years from now, the hotter, brighter Sun will boil off all water from Earth.[45] At that point, life on Earth will no longer be possible. After 4 billion years of evolution, life on Earth may have another 1 billion years left.

After another few billion years, the Sun will exhaust its hydrogen and convert to burning helium, swelling into a massive Red Giant star extending out beyond the current orbit of Earth.[46] The Earth itself is not expected to survive. Hundreds of billions of years later, all stars are expected to burn out and the Universe will go dark.[47] At this distant point in the evolution of our Universe: "There will be no energy or structures of any kind – just a cold, eternal mist of far flung particles."[48] Entropy will prevail. At least, this is the current cosmological prediction.

But the take home message from this is not that Earth, life on Earth, and the Universe will end in the distant future, rather that Earth will likely remain a sublimely habitable planet for hundreds of millions of years to come. Life on Earth is the precious here and now, and will survive for an unimaginably long time. But as discussed in Section II (Paradise Lost), we are currently destroying this precious here and now. Unless we change our destructive ways this decade, *H. sapiens* will be gone in a blink of geologic time (e.g., this century), and we will not be around to worry about these distant astrophysical threats**.** This is our immediate imperative.

It is hard to imagine a more a sublimely perfect, habitable planet than Earth.

The Great Filter

Where is everyone?

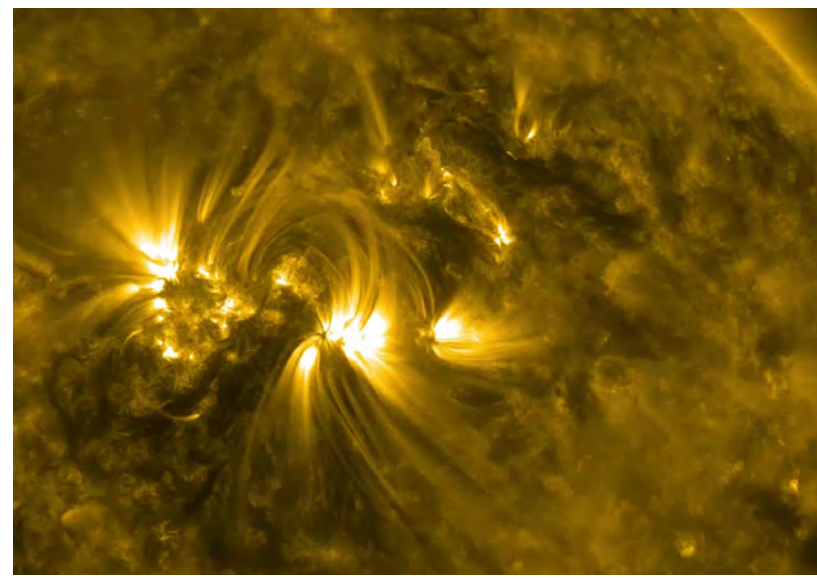
The enormity of space and time is fun to imagine, but virtually impossible for our small primate-minds to comprehend. As enormous and old as it is, it seems likely that life, even intelligent life, has evolved on many planets across the Universe. But as we continue to search for signals of alien civilizations, some astronomers now speculate that none may actually exist due to a universal threshold beyond which intelligent civilizations cannot and do not survive. They have called this "The Great Filter."

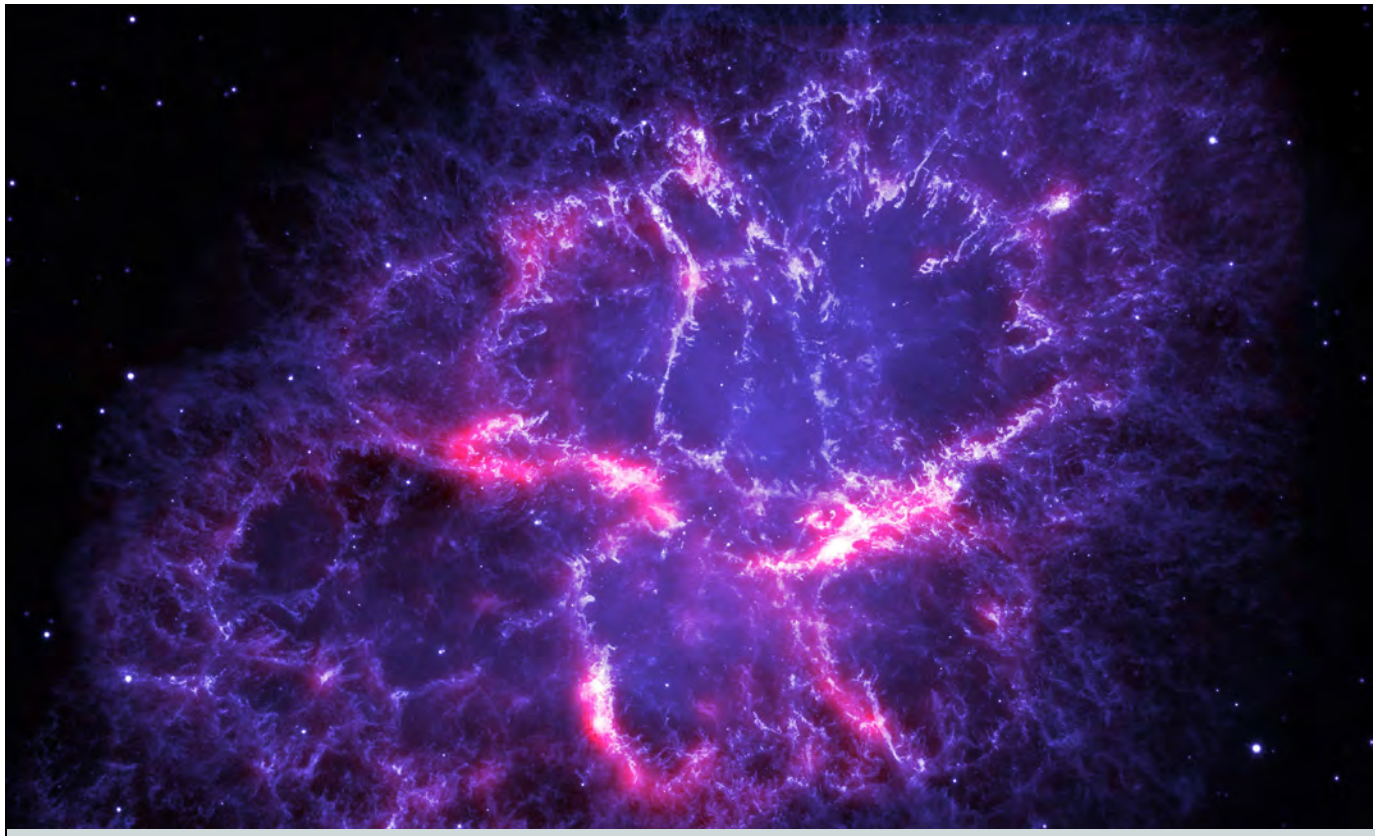
Looking into a clear night sky, we can see at most 2,500 stars (about one hundred millionth of the stars just in our home Milky Way galaxy), and most are less than 1,000 light-years away (less than 1% of the diameter of the galaxy).[49] Astronomers estimate that there are between 100 billion - 400 billion stars just in our home galaxy, and over 2 trillion galaxies across the observable Universe.[50] An oft quoted figure for the total number of stars in the Universe is from 10^{22} to 10^{24}, and that there are perhaps 10,000 stars for every grain of sand on Earth's beaches.[51]

As science writer Tim Urban notes, if only 5% of these stars are "sun-like" (similar size, luminosity, and temperature), that would give some 500 quintillion (billion, billion) sun-like stars.[52] And if (as has been estimated) perhaps 22% of these sun-like stars may have Earth-like planets revolving in the star's habitable zone, that would result in approximately 1% of the total stars in the Universe with potentially habitable Earth-like planets, or 100 quintillion (e.g., 100 Earth-like planets for every grain of sand on Earth's beaches). So far, over 4,000 exoplanets (planets outside our solar system) have been discovered just in nearby space, and at least 47 are thought to be in potentially habitable zones.[53] Astronomers predict that the recently launched "Transiting Exoplanet Survey Satellite" (TESS), could identify another 4,400 exoplanets.[54]

Hypothetically, if just 1% of the predicted Earth-like planets across the Universe develops life, and 1% of these living planets evolve intelligent civilizations, then there should be perhaps 10 quadrillion (million billion) intelligent civilizations in the Universe.[55] In our galaxy alone, there may be as many as 1 billion Earth-like planets and 100,000 intelligent civilizations.[56] There is no scientific basis for the 1% figure used in this example, but it provides a useful illustration of the probabilities.

In 1961, astronomer Frank Drake developed what is now known as the "Drake Equation" to conceptually predict the number of intelligent civilizations in the Milky Way galaxy.[57] The Drake equation predicts the number of intelligent civilizations in the Milky Way galaxy, using





Some speculate that intelligent alien civilizations may not exist due to a universal threshold beyond which they do not survive. Astronomers call this "The Great Filter."

estimates of the number stars with planetary systems, planets in habitable zones around their stars, planets where intelligent life evolves, and so on. The potential number of civilizations across the known Universe then would be the number predicted in the Milky Way galaxy times 2 trillion - the estimated number of galaxies in the observable Universe.[58] Given these odds, many feel the probability of intelligent life elsewhere in the Universe should be essentially 100%.

But given this astronomical probability for intelligent life in the Universe and even within our home galaxy, then, as Physicist Enrico Fermi asked, "Where is everyone?" This has become known as "The Fermi Paradox." Or, as others have asked, "What happened to everyone?" After extensive searching for evidence of extraterrestrial life for decades, humans have yet to detect any signal from another advanced civilization. Why?

As discussed by Urban, while there is no answer (yet) to this question, there are two categories of potential explanations.

One possible explanation for the Fermi Paradox is that technologically advanced alien civilizations are indeed out there, but we remain unaware of them for a variety of reasons, such as: extraterrestrial civilizations may have visited Earth before humans were around to witness such (e.g., prior to 50,000 years ago); Earth is in a distant "rural" district of the galaxy not yet reached by advanced colonists; alien civilizations may be perfectly content where they are, and have no desire to reach out to explore across the galaxy and intergalactic space; intelligent civilizations across the Universe do not wish to broadcast their presence and location due to the risk of hostile alien incursions; advanced civilizations that evolve anywhere are all quickly exterminated by other hostile alien civilizations; aliens are there and communicating, but we are unable to detect or interpret their signals; aliens are there, but are simply observing us without contact or interference (the "zoo hypothesis"); or that we are completely wrong about our reality and the Universe.[59]

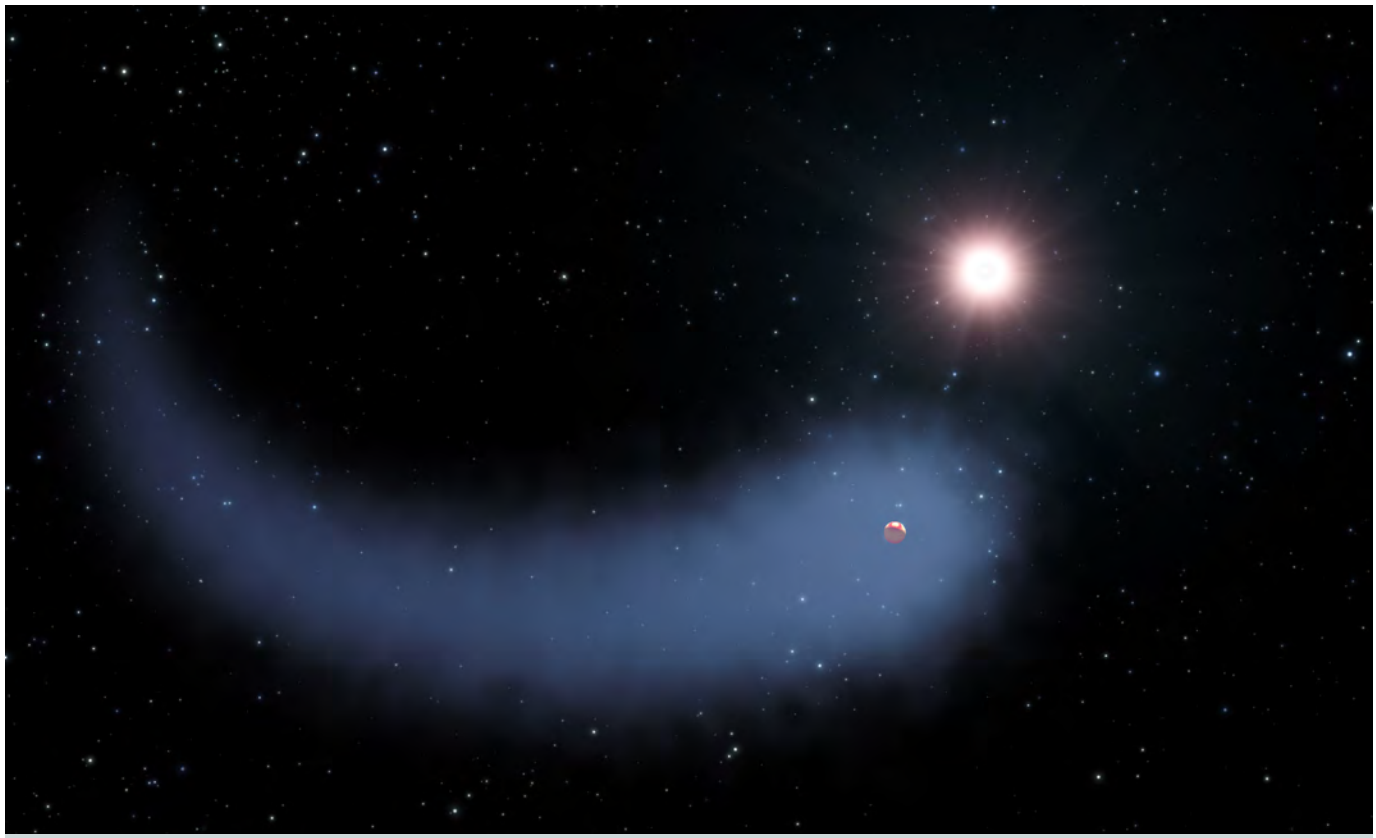
The other intriguing possible explanation for why there are no signs of advanced civilizations is that there simply are none. While probability suggests there should be thousands of intelligent civilizations in our home galaxy alone, it may be that there is a universal, cataclysmic threshold beyond which it is impossible for intelligent civilizations to continue to evolve - "The Great Filter." A Great Filter could include cataclysmic off-planet events such as extinction level asteroid impacts; massive gamma ray bursts killing all life forms; stars growing too hot and bright, rendering life on orbiting planets no longer possible (as is predicted in our solar system a billion+ years from now); the difficulty of microbial organisms incorporating bacteria as mitochondria into cells, precluding the evolution of multicellular life; eruption of super volcanoes (such as the 20 known on Earth); or self-imposed cataclysms such as exhausting the life support systems of the planet (precisely what we are now doing on Earth), climate change, or nuclear annihilation; or any/all of the above.

Some speculate (hope) that life on Earth has already passed its Great Filter horizon, and thus our technological civilization is simply rare or early in the evolution of the Universe. But another more worrying possibility is that the Great Filter remains in our future. If so, this would mean that life across the Universe may have often evolved to our stage of development, but then hits an insurmountable threshold, cannot advance further, and collapses. This is clearly the most ominous scenario, as we, like other civilizations, would almost certainly not survive such a threshold event. It is even possible that several Great Filters continually present over time with life-or-death challenges to the evolution of intelligent civilizations.

Whether we have already passed such a threshold on Earth, it is perfectly clear that our current self-imposed environmental collapse is indeed a Great Filter horizon. Either we will recognize and correct our self-destructive behavior, or we will surely become another failed evolutionary experiment. Failure to transcend such a self-destructive threshold may indeed have been what happened to other "intelligent" civilizations across the Universe. If so, perhaps we should revise our definition of "intelligent civilization."

Two interacting galaxies UGC 1810 and UGC 1813, Hubble Space Telescope.

No Planet B



An immense cloud of hydrogen from a Neptune-sized hot, rocky exoplanet orbiting nearby GJ 436 red dwarf star 30 light-years from Earth, NASA.

Some suggest that, as Earth becomes uninhabitable, human civilization may simply move to other habitable planets. This notion is often invoked to excuse or dismiss the destruction of our Home Planet: "Why worry - when we destroy Earth, we can just move elsewhere." But due to the vast distances and times involved, the probabilities of relocating to another habitable planet are extremely remote, at least with current and foreseeable space travel technology.

For instance, the closest exoplanet to Earth, Proxima Centauri b (discovered in 2016) orbiting the closest star to our solar system, Proxima Centauri, is "only" 4.25 light years away.[60] A light year is approximately 6 trillion miles, thus this closest exoplanet is more than 25 trillion miles from Earth. With today's space transport technology (Apollo 10 was the fastest manned space transit at 25,000 mph, and the unmanned New Horizons spacecraft is now traveling at 36,000 mph), it would take between 78,000 years (at New Horizons' speed) and 114,000 years (at Apollo 10 speed) to reach Proxima Centauri b. Further, it remains questionable whether Proxima Centauri b is even habitable, as it currently receives 60 times the amount of high-energy radiation as Earth, and may have lost whatever water and atmosphere it had long ago.[61] As the planet is tidally locked and always faces its parent star (just as Earth's moon always faces Earth), it is likely that the illuminated side is too hot, and the dark side too cold for liquid water to exist (although one ocean/atmosphere model for Proxima Centauri b suggests that heat may transfer from its lighted side to its dark side, maintaining a band of liquid water around the equatorial region).[62] But habitability of this closest exoplanet remains speculative, and realistically, the planet is far too distant for humans to reach with present space travel technology. Other exoplanets are far

more distant from Earth. The distance to potentially habitable exoplanets is so vast that we are unlikely to be able to reach them.

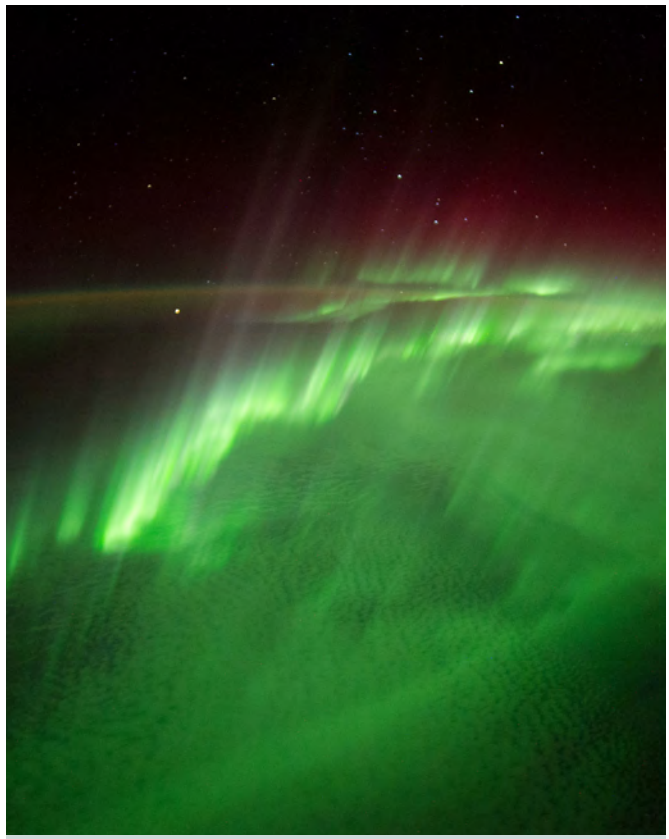
And "terraforming" Mars (making it Earth-like) to become habitable for human settlement is an extremely remote prospect as well. Mars has a very thin atmosphere of 95% CO^2 (toxic to humans), only 0.6% of the atmospheric pressure of Earth, and average surface temperature of -63°C/-81°F (and as low as -143°C/-225°F). While ripe for science fiction, the notion of terraforming Mars presents insurmountable technological hurdles that, as NASA says, are: "well beyond today's capabilities."[63] Dreams of terraforming proponents aside, recent NASA-sponsored studies confirm that there is simply too little CO^2 and water vapor in the Martian crust to create a sufficient greenhouse warming of the surface, even if one could sort out the improbable engineering feat of transferring this CO^2 and H^2O into the Martian atmosphere.[64]

It is clear that our technological development will be outpaced by the environmental decline of our Home Planet. Thus, we must abandon the notion of moving to some other planet, and focus instead on restoring and protecting the habitability of Earth as our only realistic option for survival. There really is no "Planet B."

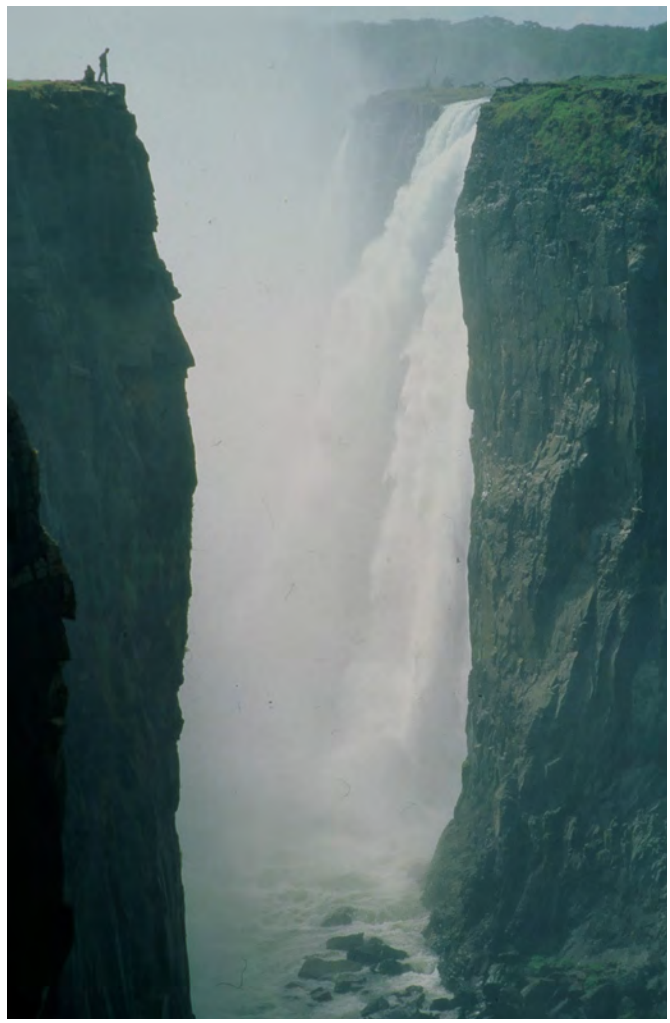
Surface of Mars. NASA confirms that terraforming Mars is "well beyond today's capabilities."

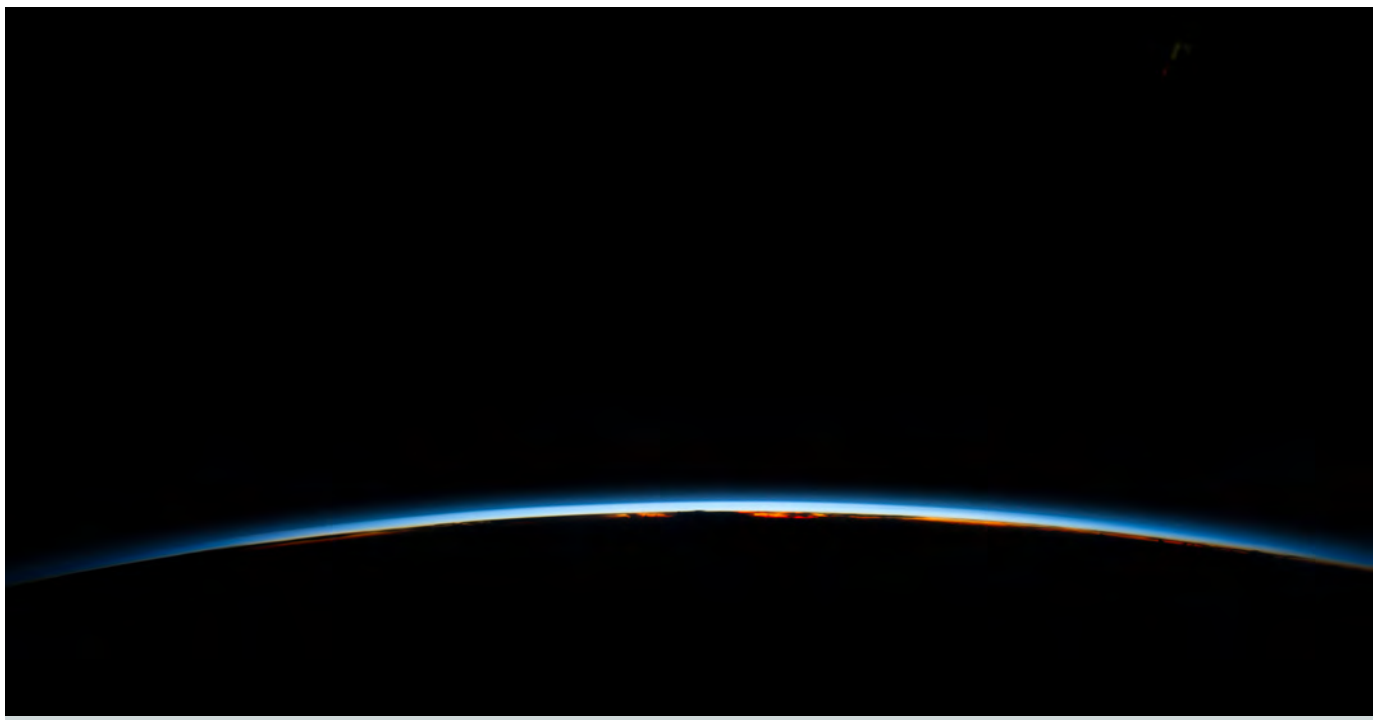
Our Home Planet

Our living, wet, warm Home Planet provides everything we need as we drift through the cold (-270°C/-455°F), dark, uninhabitable vacuum of space: A "grand oasis in the vastness of space…a sparkling blue and white jewel…the only home we've ever known." Long into the future, Earth will be our one and only home.

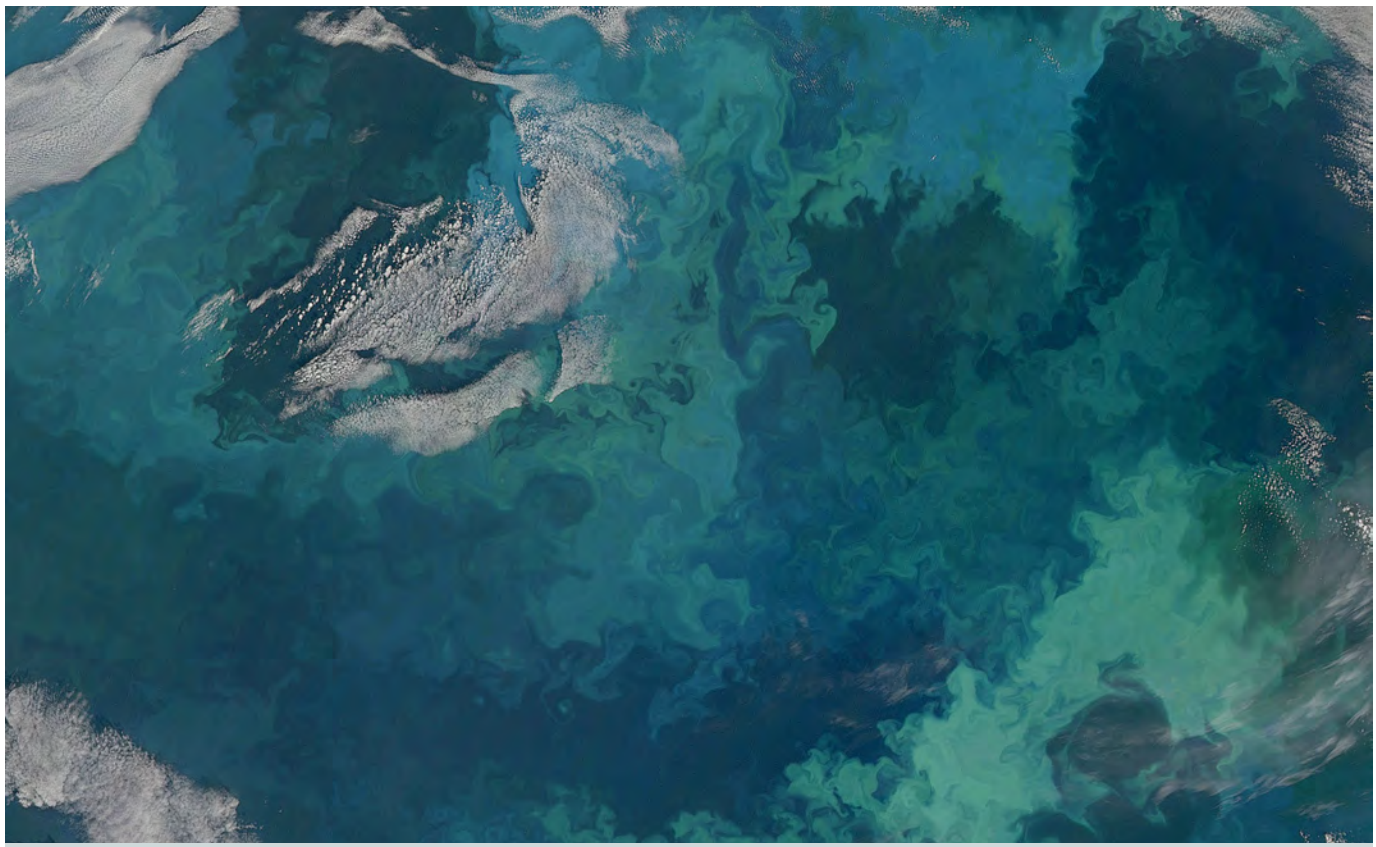


Aurora from space.

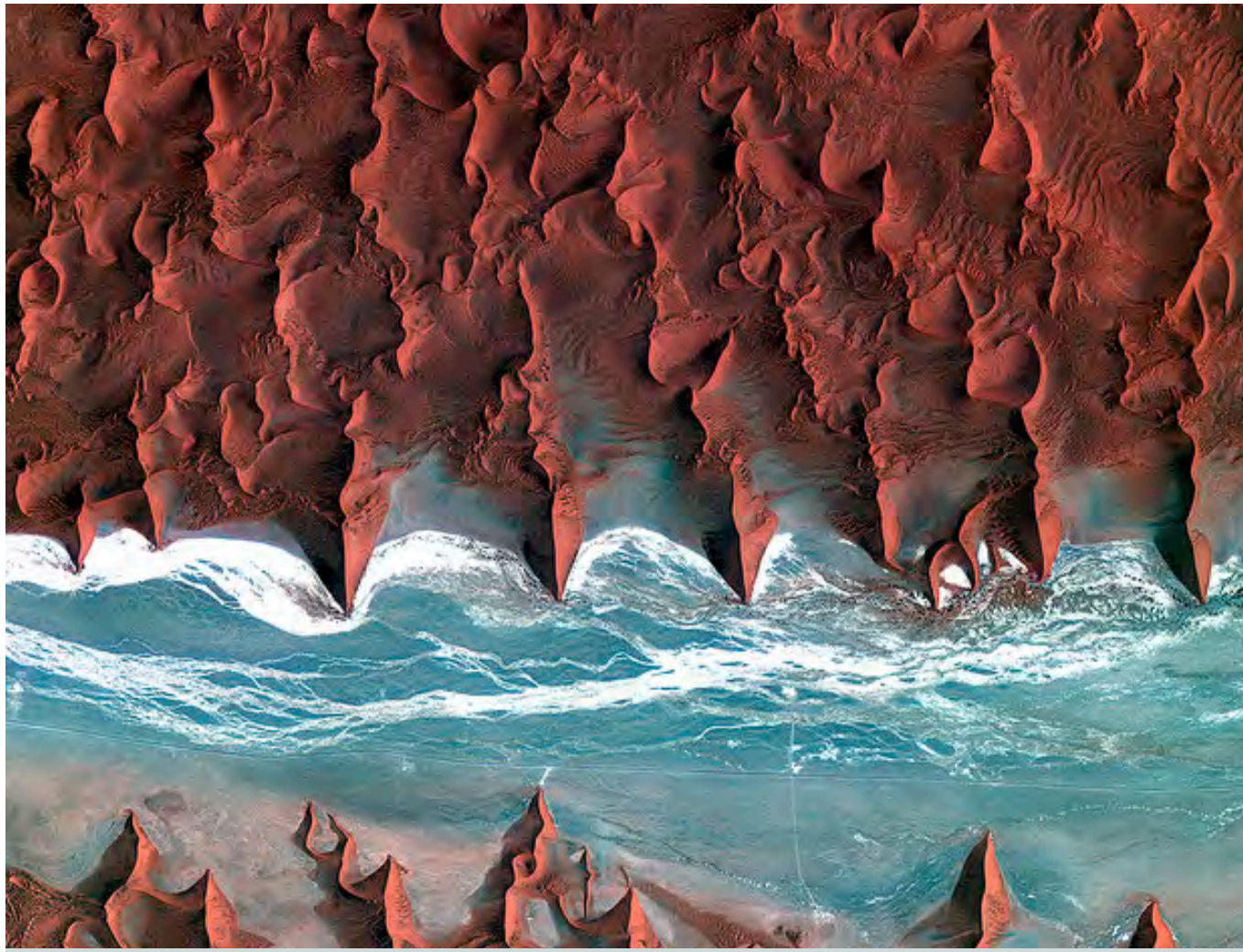




Sunrise from Earth orbit.



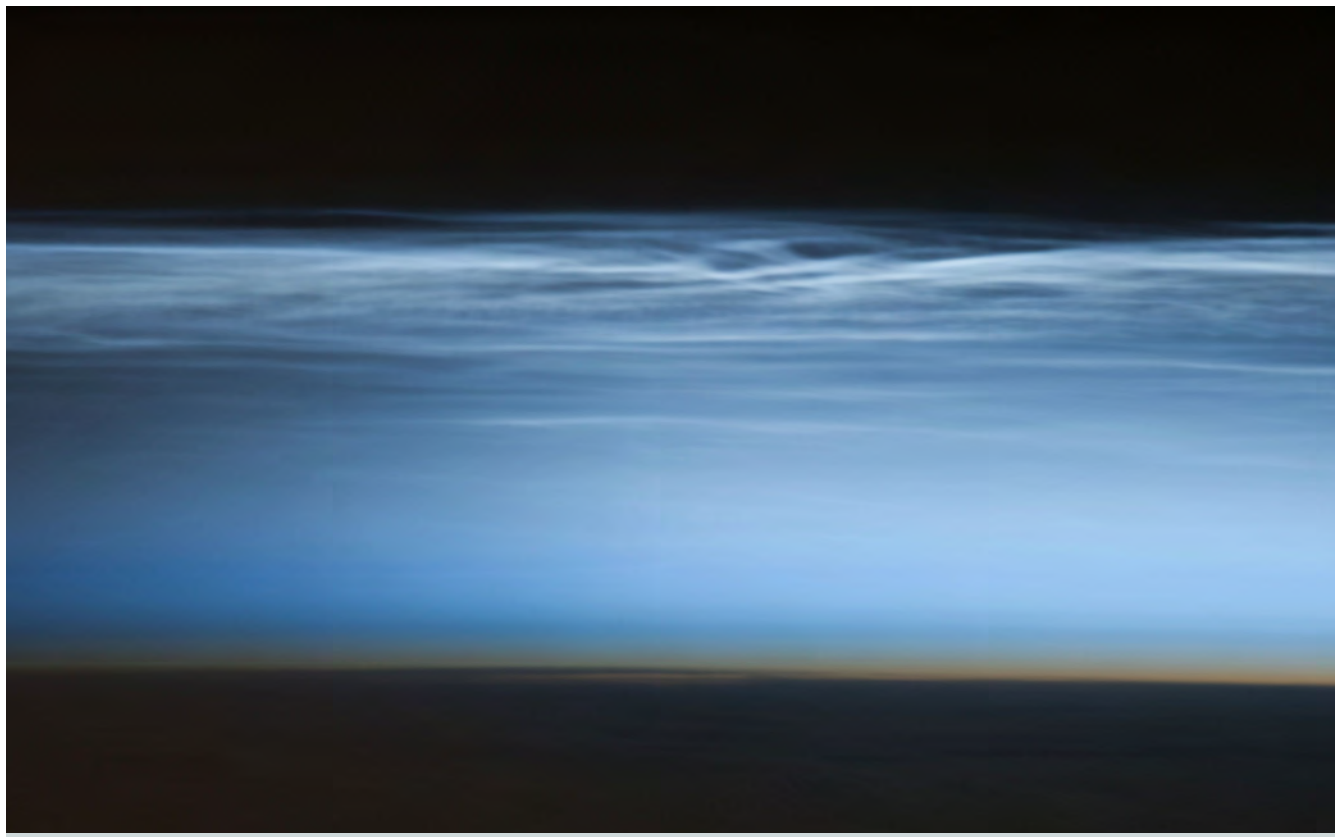
Phytoplankton bloom over hundreds of square miles of the Barents Sea, Arctic Ocean, from NASA satellite imagery.



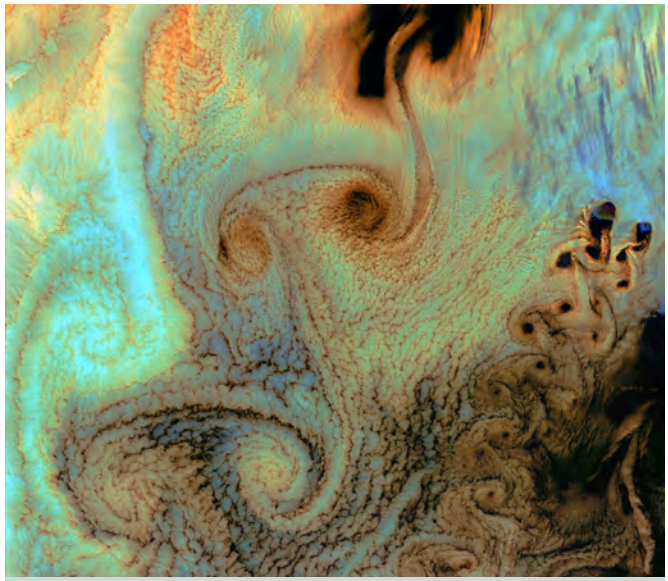
Namib Desert, Namibia, NASA.

The Mississippi River dumps over 500 million tons of sediment per year into the Gulf of Mexico.

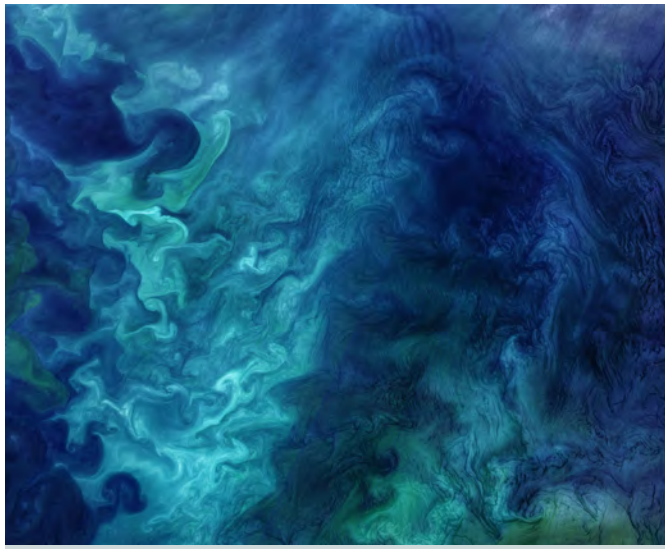
Eruption of Raikoke Volcano, Kuril Islands, Russia, into Pacific Storm, June 2019. International Space Station, NASA.



Noctilucent (polar mesospheric) clouds, 80 km over the South Pacific, from International Space Station, 2016, NASA.



Vortices of air flowing across the hundreds of square miles of Alaska's Aleutian Islands.



Phytoplankton in the Chukchi Sea, Arctic Ocean, swirls over hundreds of square miles due to mixing of Bering Sea Water with Alaska Coastal Water, June 2018.

Northwest Greenland.

As life evolved on Earth, it filled every available niche, from 7 miles high in the air to 7 miles deep in the sea, and even deep beneath the surface of the ground and seabed.

Life on Earth

As order coalesced out of the chaos of the Big Bang, from pure energy, atoms, and molecules, it then made the remarkable, mysterious leap to living cells. On Earth, about 4 billion years ago, against the force of Entropy - that tendency for the physical universe to continually run down, become more uniform and less structured - self-organizing and self-replicating systems, living beings, emerged for the first time.[65]

The huge leap from molecule to living being may have initiated from a spark of lightening in a broth of methane, ammonia, and organic molecules that had fallen to Earth, forming complex molecules such as amino acids, RNA, and proteins; or at chemosynthetic deep-sea hydrothermal vents or geysers and hot springs on land. Or, life on Earth could have begun through inoculation by extraterrestrial microbial life forms falling to Earth on dust, comets and meteorites, something known as "Panspermia," or from the subterranean "deep biosphere" (see below). Somehow, one of these mechanisms created a morphologically simple, single cell with a small tail - the prokaryotic blue-green algae/bacteria. Whatever its original source, this first single celled organism developed the ability to replicate itself. Life had begun.

The more complex Eukaryotes - predecessors to today's plants, fungi, and animals - likely evolved from the symbiotic association of different types of bacteria. Those that could burn oxygen for energy became the mitochondria in the nuclei of new living cells, those that could photosynthesize became plastids in plant cells, and so on. Mutualism, benefiting one another, became an early model for evolutionary success.

Then, about 540 million years ago, the process of biological evolution took another giant leap, forming organisms of increasing complexity - sponges, mollusks, land plants, reptiles, birds and then mammals. This is known as the Cambrian evolutionary radiation or "explosion."

Life filled every available niche, up to at least 11,278 m/37,000 feet altitude into the lower stratosphere (with suspended photosynthetic bacteria, and griffon vultures), and down to the deepest ocean depths at 10,973 m/36,000 feet deep (the Challenger Deep in the Mariana Trench). As biologist E. O. Wilson observes: "Wherever there is liquid water, organic molecules, and an energy source, there is life."[66] Life is even found to 9,144 m/30,000 feet beneath the surface of the ground and seafloor, in what is referred to as the "deep biosphere," or "Stygian realm."[67] This underground realm is inhabited by bacteria, viruses, roundworms, "zombie microbes," and archaea (a distinct type of single-celled Prokaryote) deriving energy from molecules in surrounding rock. Wilson describes "subsurface, litho-autotrophic microbial ecosystems," or "SLIMES," in this deep underground biome.[68] Some suggest that life on Earth may have originated from such underground ecosystems.

From top to bottom, the planetary biosphere stretches only about 20 miles, and within this narrow range, life is mostly concentrated within 100 meters of the land and sea surface. While the planet is over 8,000 miles in diameter, the biosphere is a preciously thin living membrane enveloping a solid and molten rock core.

Looking outward to the blackness of space, sprinkled with the glory of a Universe of lights, I saw majesty – but no welcome. Below was a welcoming planet. There, contained in the thin, moving, incredibly fragile shell of the biosphere is everything that is dear to you, all the human drama and comedy. That's where life is; that's where all the good stuff is.

LOREN ACTON, SPACE SHUTTLE ASTRONAUT, 1985[69]

Countless adaptations have allowed life to flourish in every corner of Earth's biosphere. No science fiction can be written that is more phenomenal than the wonders of real life right here on Earth. A few examples:

- Emperor penguins dive to 535 m/1,755 feet deep in the ocean to feed;
- Alaska Wood Frogs survive winter temperatures of -56°C/-70°F by flooding their tissues with glucose, stopping their hearts, stopping breathing, and freezing solid for months at a time;
- The Deep Scattering Layer of marine animals in the open ocean makes the largest migration on Earth, every day, as billions of tons of phosphorescent lantern fish, squid, and zooplankton ascend nightly from 500 m to 1,000 m depths up into surface waters to feed, and then back to deep water again each morning to avoid predators;

Biologists have identified two million species on Earth, and believe there are millions more yet to discover. A recent analysis estimates that there may be 8.7 million species on Earth, concluding that: "86% of existing species on Earth and 91% of species in the ocean still await description."

Each year scientists discover about 18,000 additional species. We are just starting to get to know the biosphere of our Home Planet, even as we are rapidly destroying it.

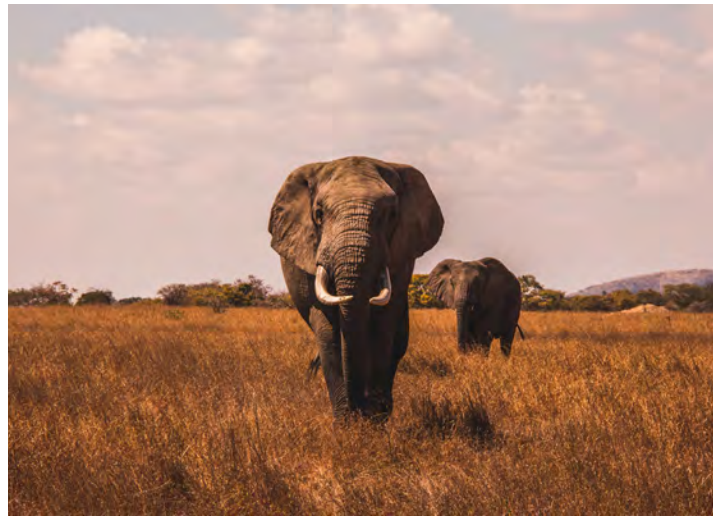
Alligator eyes at night.

- Komodo dragons' mouths are so loaded with bacteria that they simply bite their prey and wait for them to die from infection;
- Albatrosses using dynamic soaring glide hundreds of miles in winds without flapping their wings, can stay at sea over 5 years at a time, fly over 10,000 miles in one flight, and make entire circuits of the planet;
- Giant Sequoia trees can grow to 31 m/102 feet in circumference, weigh over 1,000 tons, and live over 3,500 years;
- Blue Whales, the largest animal ever to have lived, are also the loudest, communicating in ultra low frequencies across thousands of miles of ocean, through mid-oceanic sound channels, at over 180 decibels (louder than a jet engine on takeoff), and in different dialects;
- Pacific Salmon juveniles imprint on the precise chemical signature of their natal stream, and after migrating for years across thousands of miles of open ocean, return to spawn in the exact stream from which they emerged;
- Homing Pigeons and other birds have remarkable and mysterious navigation abilities, using internal olfactory and magnetic maps, landmarks, and sun and star compasses, allowing them to quickly return to an exact spot after being transferred thousands of miles away to an unfamiliar area;
- Kangaroo rats survive in deserts without ever drinking water, getting all the water they need from the seeds they eat;
- Polar fishes synthesize blood antifreeze proteins allowing them to survive at sub-zero water temperatures;
- Mexican Axolotls (critically endangered salamanders) can regenerate limbs, tails, hearts, brains, and neurons in formerly paralyzed limbs;
- African bullfrogs survive drought by covering themselves in mucous cocoons and going dormant in the mud for up to seven years;
- Peregrine falcons, the fastest animal on Earth, dive at over 240 miles per hour;
- Tubeworms at deep sea hydrothermal vents survive by chemosynthesis, using hydrogen sulfide toxic to most organisms, rather than photosynthesis;
- Cuvier's beaked whales dive to 2,992 m/9,874 feet deep, holding their breath for over two hours;
- Ruby-throated Hummingbirds flap their wings 200 times per second;
- Cheetahs, the fastest mammal, can run at over 70 mph;
- Arctic terns migrate 50,000 miles each year, from Arctic to Antarctic and back, over 30 years of life traveling more than a million miles;
- Deep sea anglerfishes (with over 300 species) attract prey in the dark ocean depths with a luminescent bulb at the end of a fishing-rod-like elongated dorsal fin ray dangling in front of their mouths;
- Ruppell's griffon vultures fly at 11,278 m/37,000 feet altitude with special hemoglobin to enhance oxygen uptake;

- Goliath Frogs in west Africa (weighing almost 3 kg) build ponds for their eggs by moving rocks weighing over 2 kg to dam streams;
- Bar-tailed Godwits fly over 7,000 miles from Alaska to New Zealand in nine days over the Pacific Ocean without stopping;
- Sharks, with electroreceptors in their skin, can detect electric fields as weak as a flashlight battery connected to electrodes 16,000 km/10,000 miles away, down to one millionth of a volt that they use to locate prey;
- Tiny invertebrate corals, with photosynthetic symbionts in their tissues providing them energy, collectively built the largest living structure on Earth, Australia's Great Barrier Reef, stretching over 1,200 miles and covering 135,000 mi^2;
- Black Marlin swim at speeds of 80 mph, the fastest marine animal;
- White Sharks and Basking Sharks swim thousands of miles, across entire oceans;
- A "Honey Fungus" colony in Oregon covers 3.7 mi^2, is 2,000 years old, and acts like one individual organism, making it the largest organism on Earth;
- Central American hairy tree frogs, when threatened, break their own toe bones and push them through their feet to form sharp claws;
- Termites in Guinea accumulate toxins throughout their life, and if the hive is threatened, explode spraying toxins upon the attackers;
- Zombie Worms secrete acid, turning prey into mush which they then absorb through their skin;
- Diving Bell Spiders capture air bubbles allowing them to stay submerged for an entire day;
- Indonesian Mimic Octopus can assume the characteristics of 15 different marine organisms;
- Lungless Frogs of Borneo breathe through the skin;
- Bowerbirds make elaborate nests with sticks, feathers, and plastic items to attract a mate.[70]

This list of extraordinary adaptations could go on for many more pages.

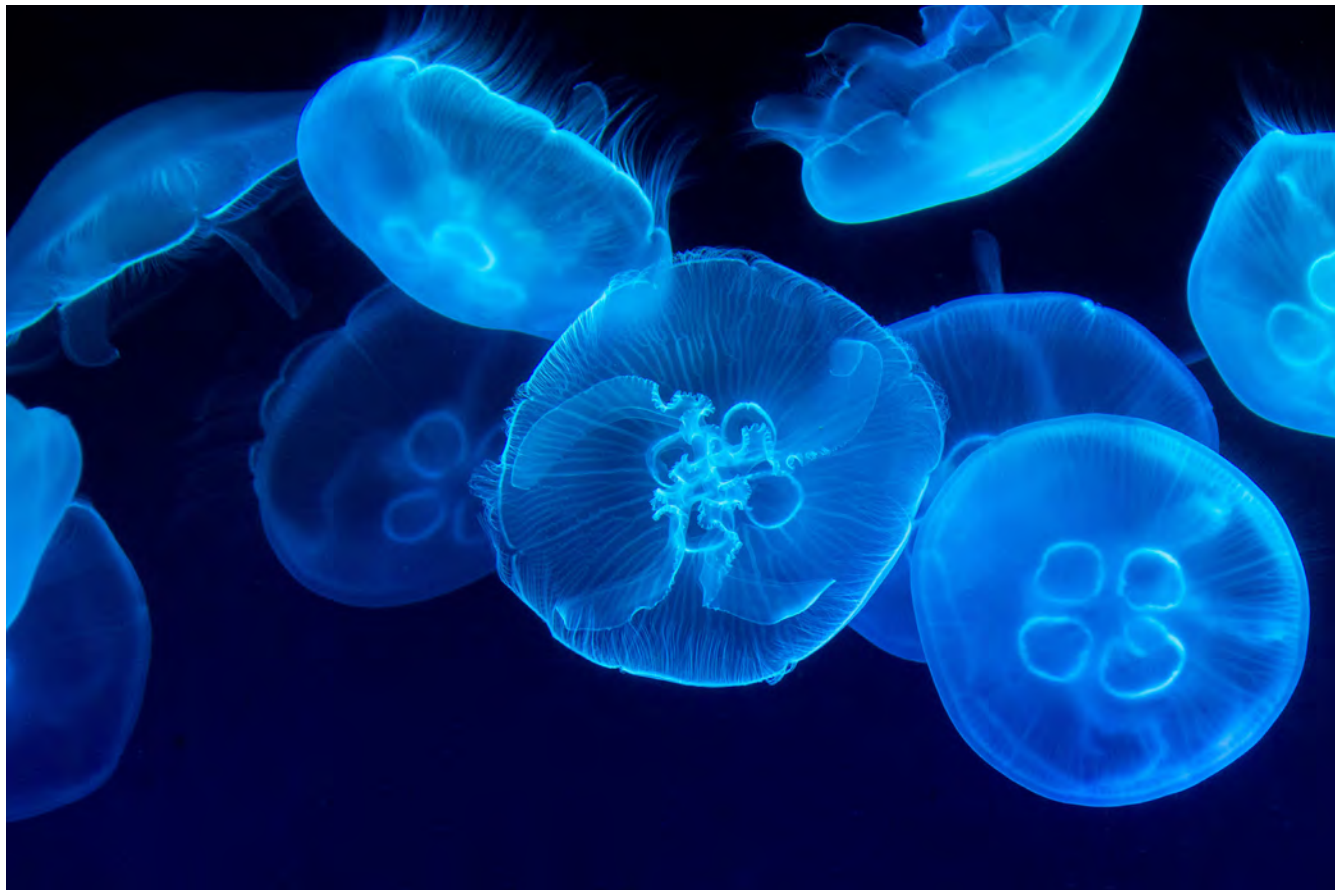
And life has adapted to some of the most extreme environments imaginable, such as "extremophiles" living at deep-sea hydrothermal vents in waters at 148°C/300°F; the bitterly cold and dry Antarctic dry valleys; inside sea ice and on glaciers; hypersaline ponds; acidic waters of hot springs and geysers; the driest deserts of the world; and in ocean depths with water pressures of 8 tons per square inch (1,000 times surface pressure) at 10,973 m/36,000 feet deep. As Liz Langley writes: "Extremophiles not only do exceptional things, they've opened our minds about what life is and what kind of environments can support it, widening our view of the potential for life on other planets."[71]



The more we learn about other species, the less unique Homo sapiens *seems to be. Many species collect and process information about their environment, learn, remember, reason, problem-solve, communicate, teach, have complex emotions, act altruistically, anticipate the future, have individual personalities, and are self-aware. Humanity is now undergoing a philosophical paradigm shift from Anthropocentric to Ecocentric.*

For instance, the phenomenal tardigrades, one millimeter-long aquatic organisms that look like "a manatee wearing a space suit for Halloween," can tolerate temperatures from -200°C/-328°F up to 151°C/304°F, severe lack of oxygen and water, high pressure, the vacuum of space, and radioactivity a thousand times what humans can tolerate.[72,73] When stressed, the 160+ species of tardigrades can shut down their metabolism (cryptobiosis) for decades. Other amazing extremophiles include brine shrimp thriving in places like the Great Salt Lake that are ten times saltier than the ocean; cold-resistant Arctic bacteria; methane ice worms on the seabed of the Gulf of Mexico; ice worms thriving on surfaces of glaciers; the "rushing fireball" microbe *Pyrococcus furiosus*, that thrives in hydrothermal sediments at the boiling point of water, 100°C/212°F; and the radiation-resistant bacteria *Dienococcus radiodurans* that can tolerate 3,000 times the radiation that humans can, actually repairing its strands of DNA broken by radiation.[74] Caves sealed off from the surface for millions of years have been found with autotrophic bacteria that metabolize hydrogen sulfide from rocks, supporting rich invertebrate ecosystems with pill bugs, millipedes, bristletails, scorpions, and spiders.[75]

Many animals can live for hundreds of years, including ocean quahog clams, tuatara lizards, bowhead whales, tubeworms, Greenland sharks, koi, tortoises, Antarctic sponges, and the "immortal jellyfish" hydrozoan *Turritopsis dohrnii* (which recycles from adult to immature polyp and back again and may actually be immortal). In the plant world, a clonal Jurupa oak in California is now more than 13,000 years old; a clonal colony of quaking aspen is estimated at 80,000 years old; an individual bristlecone pine at 5,000 years old; and many other individual plants live for several thousand years. Some scientists claim *Bacillus* spores from geological salt deposits in New Mexico were revived after 240 million years in dormancy, while others dispute this claim. But certainly, bacteria have been revived after being dormant for 34,000 years in salt formations. How the cells remain viable for so many millennia remains a mystery.[76]



To date, biologists have identified and described two million species. The most familiar life forms, the vertebrates, include reptiles (10,000 species identified), amphibians (6,700 species), birds (11,000 species), fish (32,000 species), and mammals (5,700 species), for a total of at least 65,400 vertebrate species known today.

But clearly the non-vertebrate life forms dominate Earth's biosphere: insects (963,000 species), plants (400,000), fungi and lichens (100,000), protozoans and algae (80,000), spiders and scorpions (75,000), mollusks (70,000), crustaceans (40,000), nematode worms (25,000), flatworms (20,000), annelid worms (12,000), corals and jellyfish (10,000), sponges (10,000), bacteria and archaea (4,000), and others (10,000).[77]

And scientists believe there are millions more species yet to discover. One recent analysis estimates that there may be 8.7 million species on Earth (+/- 1.3 million), of which 2.2 million are marine species (+/- 0.18 million).[78] This study concludes: "86% of existing species on Earth and 91% of species in the ocean still await description." Another study estimates that there are approximately 5 million, plus or minus 3 million, species on Earth.[79] Forest canopies and the deep ocean remain poorly explored. And of the 2 million species that have been described, less than 1% of these do we know much about – e.g., life histories, distribution, and ecological roles.

Amazingly, each year scientists discover about 18,000 more species.[80] Some recently discovered species include:

- Olinguito (*Bassaricyon neblina*), a mammal in the raccoon family endemic to the high forests of the Andes in Ecuador and Colombia;
- Kaweesak's Dragon Tree (*Dracaena kaweesakii*), endemic to the limestone mountains of Thailand;
- ANDRILL Anemone (*Edwardsiella andrillae*) living embedded in the underside of the Ross Ice Shelf in Antarctica;
- Skeleton Shrimp (*Liropus minisculus*), a caprellid amphipod found in an underwater cave off the California coast;
- Orange Penicillium (*Penicillium vanoranjei*), a drought-resistant fungus in soils of Tunisia;
- Leaf-Tailed Gecko (*Saltuarius eximius*), a nocturnal gecko isolated for millions of years on a rainforest mountain top in Australia;
- Amoeboid Protist (*Spiculosiphon oceana*), a 5 cm-long, single-celled organism in an underwater cave off the coast of Spain;
- Clean Room Microbes (*Tersicoccus phoenicis*), discovered in sanitized "clean rooms" for construction of spacecraft;
- Tinkerbell Fairyfly (*Tinkerbella nana*), a tiny Costa Rica arthropod less than 250 microns long;
- Domed Land Snail (*Zospeum tholussum*), a blind, 1-2 mm-long snail found 1 km underground in the Lukina-Jama Trojama cave in Croatia.[81]

Clearly, we are just starting to get to know the biosphere of our Home Planet, even as we are rapidly destroying it.

Recent DNA analysis of the micro-biome points to the stunning conclusion that all living beings today may

have evolved from a single cell approximately 3.5 billion years ago, called the "Last Universal Common Ancestor" (LUCA), or "microbial Eve."[82] It is thought that this single anaerobic cell likely inhabited deep-sea hydrothermal vents at the time, and was similar to today's anaerobic *Clostridium* bacteria or hydrogen-reliant archaea. The remarkable implication of this suggestion is that, indeed, all living organisms on Earth are related to each other. This concept of a singular ancestry was actually first proposed by Charles Darwin in his 1859 *The Origin of Species*:

> ***Therefore I should infer from analogy that probably all the organic beings which have ever lived on this earth have descended from some one primordial form, into which life was first breathed....There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one.***
>
> CHARLES DARWIN, BIOLOGIST, 1859[83]

And this extraordinary biological diversity on Earth - the millions of species and trillions of individual organisms with whom we share the biosphere - provides all of our food, oxygen, many of our pharmaceuticals, and all ecological services (such as clean air and water, oxygen, nutrient cycling, and waste disposal), for free.

The total biomass of Earth was recently estimated at approximately 550 billion tons (gigatons) of dry carbon, with plants (mostly land plants) comprising 80% of the total biomass of 450 gigatons, bacteria at 70 gigatons, fungi 12 gigatons, archaea 7 gigatons, protists 4 gigatons, and all animals – including all marine and terrestrial arthropods, other invertebrates, and all vertebrates – collectively weighing only about 2 gigatons.[84] E. O. Wilson suggests that the most numerous organism on Earth may be a newly described tiny viral bacteriophage called "HTVC010P," with billions per milliliter of seawater across the sea surface.[85] Wilson wonders whether there may be even more microscopic scavengers and predators too small to be detected by conventional microscopy, calling them "marine dark matter."

The largest and least understood component of the biosphere is the deep-sea (below 1,000 meters depth), which covers 60% of the planet surface, and by volume comprises over 90% of the entire biosphere.[86] This mysterious biome has no sunlight, low physical energy, low temperatures, extreme pressure, high biodiversity, and high sensitivity to human disturbance. The deep sea is lit only by an ethereal, diffuse, blue-green bioluminescence. Fewer people have been to the deep ocean than to outer space. And while the entire surface of Venus, Mars, and the Moon have been mapped at a resolution of 100-meters, less than 0.05% of Earth's ocean floor has been mapped at a comparable scale.[87]

The deep sea bed is intersected by huge submarine canyons, the longest mountain range on Earth (the mid-ocean ridge), over 45,000 submerged seamounts with a combined surface area the size of Africa, chemosynthetic vent ecosystems with 6-foot tall tube worms, sea floor brine pools (hypersaline "lakes within oceans"), and countless mysteries yet unknown to science.

Bioluminescent mid-water squid Abralia veranyi. *The largest and least understood component of Earth's biosphere is the deep sea (below 1,000 meters depth), which by volume comprises over 90% of the entire biosphere. This mysterious biome has no sunlight, low physical energy, low temperatures, extreme pressure, high biodiversity, and high sensitivity to human disturbance.*

The deep sea pelagic (water column) zone is the scene of the largest animal migration on Earth — the daily vertical migration of the "deep scattering layer," of zooplankton, bioluminescent "lantern fish," squid and other organisms which nightly ascend as much as one kilometer to feed, descending again at daybreak. Many species in this "Alice in Wonderland" deep ocean world have evolved unique genetic and molecular adaptations.

Some scientists think there could be as many as 10 million species in the deep sea, few of which are known to science. Deep-sea benthic ecologist Fred Grassle says: "The deep-sea may, in fact, rival tropical rainforests in terms of the numbers of species present."[88] The 10-year Census of Marine Life catalogued over 120,000 marine species, and predicts another 750,000 species as yet undiscovered.[89]

Finally, to fully appreciate the extraordinary nature of life on Earth, we must transcend the Anthropocentric (human-centered) mindset through which we traditionally view the non-human world. Environmental sociologists speak of the Human Exceptionalism Paradigm (HEP), which assumes that *H. sapiens* is fundamentally different from, and superior to, all other non-human life forms. This arrogance has allowed us to rationalize the exploitation of nature, but science is now redefining our place within the natural world, and the very nature of intelligence. As it turns out, we aren't as exceptional as we may want to believe.

In fact, many species collect and process information about their environment; learn, remember, reason, problem-solve, communicate, teach, have complex emotions, act altruistically, anticipate the future, have individual personalities, are self-aware, and are self-reflective. Some examples of intelligence in non-human species:

- Octopuses have excellent memories, execute complex tasks (such as opening jars to retrieve food items), learn and practice deception, and can learn new skills from an early age;
- Dolphins communicate with well developed, distinct dialects, learn and teach one another, are self-aware,

have individual personalities, think about the future, and develop cultural traditions that they pass along to future generations;

- Chimpanzees, our closest relative, use tools, are highly social, have well developed memories, and teach one another;
- Elephants, with the largest brain of any land animal, display complex emotions such as happiness, compassion, fear, and pain; act with compassion, altruism, and self-awareness, and are well known to have amazing memories;
- Parrots recognize many human faces, and can mimic human language;
- Pigs are exceptionally smart, some say as smart as a three-year old human child;
- Crows build tools, use them, and save them for future use. They can reason, problem-solve, and have self-awareness;
- Rats learn and process information in specific ways, allowing them to learn their way out of constructed mazes;
- Plants are now thought to actually think (collecting, processing, and responding to environmental stimuli), communicate, learn, remember, and problem-solve;
- Plasmodial slime molds (with no brain) are able to learn, remember, solve problems, teach each other, and can heal themselves in two minutes if cut in half;
- Trees share information through underground mycorhizzal (fungal) networks some call the "wood-wide web," sharing water and nutrients, and communicating about drought, disease, and insect attacks, to which other trees respond; this involves a symbiotic relationship between tree and fungi, with fungi receiving energy from the tree's photosynthesis, and in return providing nitrogen, phosphorus, and other essential minerals needed by the tree. [90]

Clearly, intelligence, cooperation, communication, and compassion are not the sole province of *H. sapiens.* Philosophically, humanity is now undergoing a paradigm shift from Anthropocentric to Ecocentric. This Ecocentric Revolution may be as significant as the 16th century Copernican Revolution, when our ancestors discarded the Ptolemaic model of Earth at the center of the Universe, in favor of the heliocentric model of Earth revolving around the Sun. Biology today is helping us realize that we are not the center of the biosphere either, and as we discard the old Anthropocentric model, the Ecocentric Revolution is underway.

Mass Extinctions

The next fascinating part of the story is that the mere fact that a species evolves is anything but a carte-blanche ticket to survival. E. O. Wilson concludes that the average life span of species in the fossil record typically ranges from 500,000 years for mammals up to 10 million years for other species.[91] However, some species have survived virtually unchanged for hundreds of millions, even billions of years. These evolutionary champions include cyanobacteria (3 billion years), sponges (760 million years), jellyfish (550 million years), the chambered nautilus (500 million years), horseshoe crabs (445 million years), coelacanths (335 million years), and gingko trees (270 million years).

But given the fact that more than 99% of all species that have ever existed are now extinct, extinction is the rule, not the exception. Scientists estimate that over 5 billion species have gone extinct over the course of evolution of life on Earth.[92] It is clear from the fossil record that there has been a dynamic, yin/yang process of speciation/extinction/speciation occurring continuously. And life on Earth has experienced five well-known mass extinctions, in which over 75% of all species were lost.[93] We are now in the sixth mass extinction, the first caused by a single species - us.

Even before the Cambrian Era, the first, lesser-known, mass extinction event occurred about 2.4 billion years ago, when oceanic photosynthetic cyanobacteria produced more oxygen than could be absorbed by oceanic chemical oxidation (e.g., with iron). As this excess O^2 began to accumulate in the atmosphere, many obligate anaerobic organisms, with low tolerance to oxygen, were eliminated in what is now called the Great Oxygenation Event (GOE). This mass extinction of anaerobic bacteria may have contributed to the first "Snowball Earth" event (the Huronian glaciation) lasting 300 million – 400 million years.

The Cambrian evolutionary radiation beginning 540 million years ago (mya) was punctuated by the five well-known mass extinction events, where life on Earth experienced a sudden and extensive reduction (over 75%) in the total number of species, followed by a slow recovery in biodiversity taking 10 million years or more: the Ordovician extinction, 440 mya; Devonian, 370 mya; Permian, 250 mya (the most devastating extinction event so far when between 90% - 96% of all species on Earth vanished, including the iconic trilobites); Triassic, 210 mya; and perhaps the most famous, the Cretaceous extinction, 65 mya, when virtually all large vertebrates, including dinosaurs, were lost.

Large asteroids colliding with Earth caused some of these mass extinctions (such as the Chicxulub impact off the present-day Yucatan Peninsula that caused the Cretaceous extinction), and climatic shifts contributed to most. Many evolutionary biologists suggest that the Cretaceous dinosaur extinctions may have been a necessary pre-condition to allow mammals to flourish. If so, these mass-extinction events could be added to the list of coincident precursors to the evolution of life as we know it, indeed the very emergence of consciousness throughout the biosphere.

The Human Animal

Evolution continued from the first primate, first ever to walk erect *Purgatorius*, to *Proconsul*, *Australopithicus*, *Homo habilis*, *Homo erectus*, and then finally, or perhaps not finally, *Homo sapiens*. The human being is a composite of about 70 trillion living cells working together cooperatively in specialized roles in one of the most complex, interconnected systems we know.[94]

Recent studies suggest that our early hominid ancestors may have been forced out of their arboreal existence about 2.6 million years ago, into walking upright on open grasslands due to global forest fires caused by increased lightning strikes from excessive cosmic energy entering Earth's atmosphere from supernovae (exploding stars) 163 light years away.[95] This new upright, bipedal existence freed hominid hands for a variety of tool making and other tasks essential to our evolution into modern humans.

Human hearts beat 2-3 billion times in a lifetime, pumping a volume of blood that would slightly overfill an oil supertanker. The alveolar surface inside our lungs is twice the size of a football field; our entire skeleton is renewed every two years; and every second some 2-3 million new red blood cells flow from our bone marrow into the blood stream.

Interestingly, over half of the cells in the modern human body are actually non-human, called the "human microbiome" - bacteria, fungi, yeasts, archaea - with hundreds of distinct species of microorganisms inside all of us, all necessary for our survival. As it turns out, we are an ecosystem.

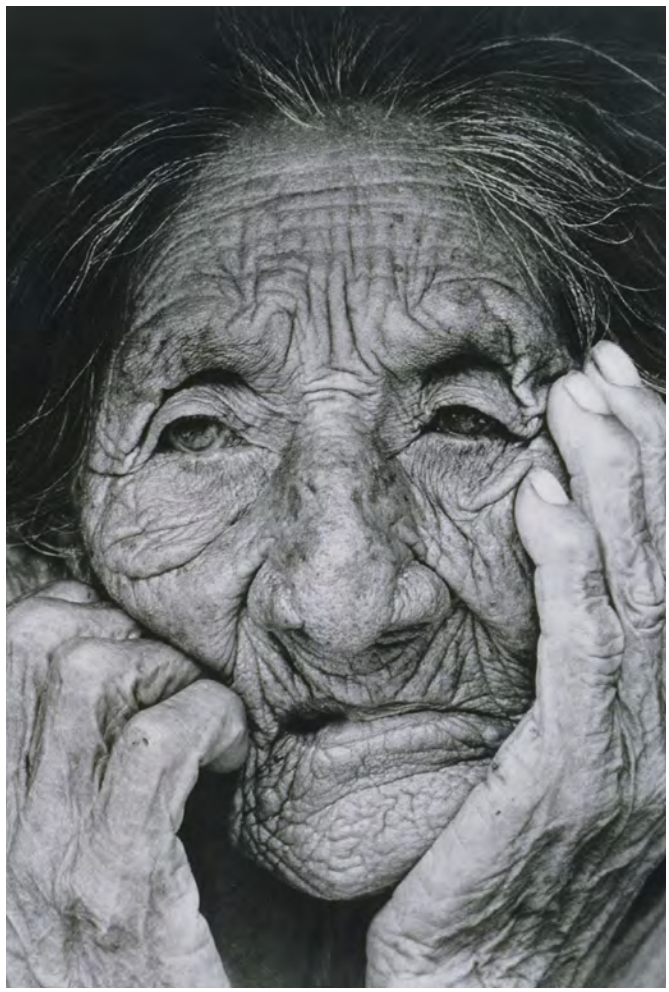
This remarkable human animal is replicated, with sexual recombination of genes from each parent, from chemical information coded by about 3 billion nucleotide base pairs (adenine, thymine, guanine, and cytosine), on about 24,000 genes, on 23 chromosomes in

the nucleus of all of our cells.[96] From this chemical instruction, the human embryo actually goes through the various stages of the evolutionary development of vertebrate life on Earth, in which ontogeny (development of the embryo) recapitulates phylogeny (evolution of life).

But the most fascinating feature of this complex creature is its enlarged, analytical, self-reflective brain that can abstract order out of sensory input (as discussed above, this is not unique to *H. sapiens*). As our arboreal primate ancestors ventured down from the trees onto the African plains, previously occupied hands were freed for a myriad of other tasks that eventually facilitated the development of propositional thought. A whole new world opened for monkey-mind.

In a relatively short time evolutionarily, brain size increased from only 400 cc in *Australopithecus afarensis* to 2000 cc in *Homo sapiens*. This reddish grey brain pulses along with about 20 watts of electrical energy at 8-10 cycles per second, producing such wonders as symphonies, skyscrapers, particle accelerators, poetry, the International Space Station, and the U.N. Earth Charter. While only 3% of our total body weight, the brain uses some 20% of all the energy we use. Despite the popular notion that we only use 10% of our brain, now neurobiologists believe that virtually every part of the brain is used, and is active much of the time. However, we may only understand about 10% of its function.

This brain/mind has glimpsed into the expansive depths of reality where common sense collapses – a magical world of curved space-time, multidimensional space, DNA, gravity waves, massless neutrinos, dark matter, dark energy, and an ever-expanding universe. Mind is indeed mystery and magic rolled into one, and is now coalescing through the interconnectedness of thought across the planet in the information age. And we have yet to begin to imagine or account for the collective mind and consciousness of all species on Earth. It seems probable that consciousness is not reserved solely to humans and is likely present throughout the biosphere.

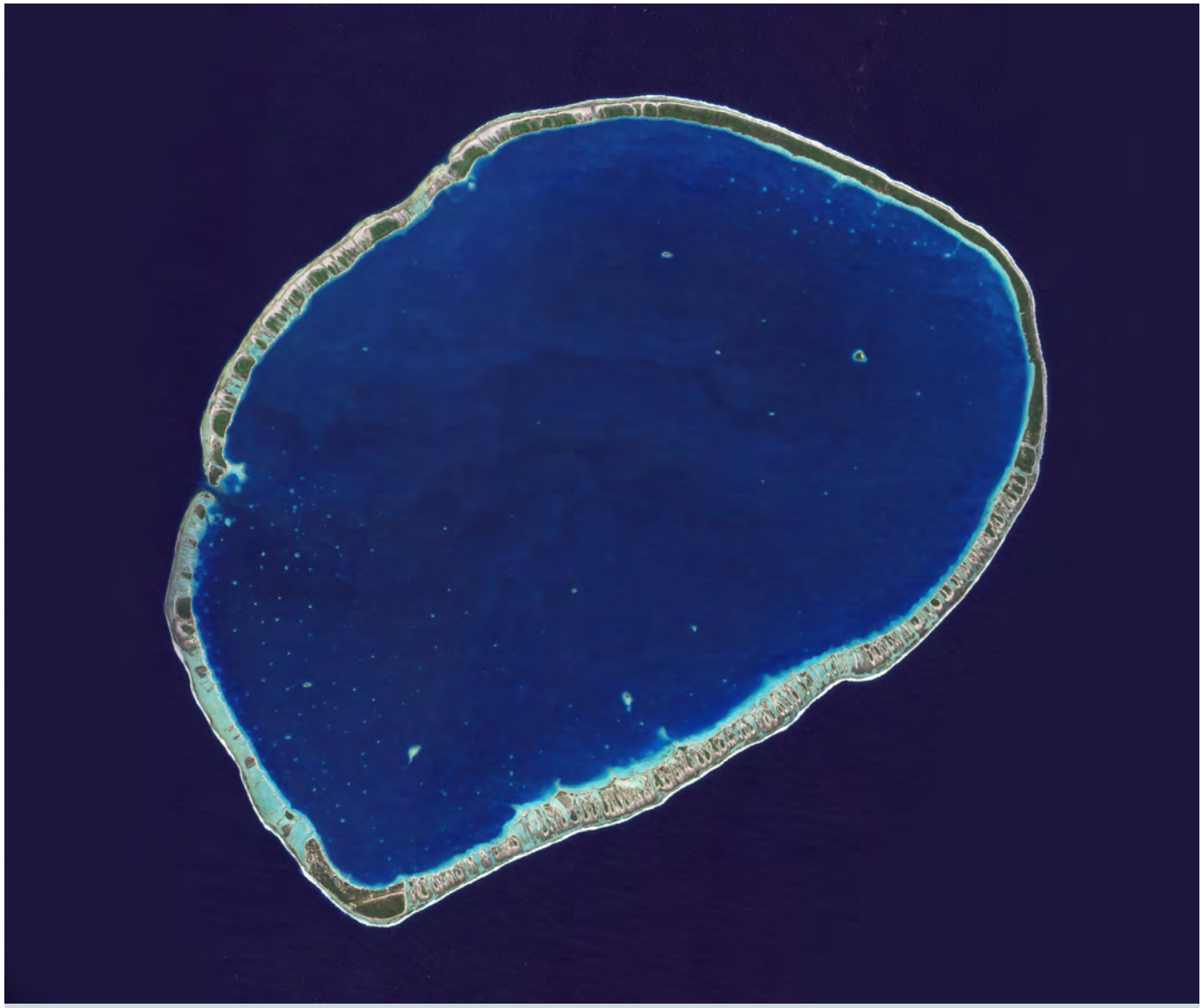


Gaia

The wealth of this world isn't in the ground, it's all around us.

JAMES CAMERON, "AVATAR," 2009[97]

It is difficult, yet instructive, to imagine the totality of all life on Earth at any one moment. At this very moment, millions of different species and trillions of individuals are all functioning together and interacting in the most exquisite, synergistic complex we know – Earth's biosphere. James Lovelock named this emergent, integrated living system "Gaia," describing the biosphere as a self-regulating organism with coevolving components, collectively controlling surface temperature, ocean chemistry, atmospheric oxygen and CO^2, cloud formation, solar insolation, and nutrient cycling, all to maintain optimal conditions for life.[98] Lovelock calls Earth's biosphere "the largest living being in the solar system." While some dispute the literal interpretation of the Gaia hypothesis, it certainly provides an evocative metaphor with which to think about Earth's biosphere.



Tikehau coral atoll, French Polynesia.

Incomprehensible Mysteries

Science is spectacularly successful in its predictive rigor and technological application. However, at its very core, science consists simply of careful observation, description, and quantitative measurement of our world. Science has not, and perhaps cannot, answer the most fundamental questions regarding the essence of physical existence. For instance, science can observe, describe, measure, and harness various forms of energy - electrical, electromagnetic, mechanical, nuclear, and gravitational. But science can't really know or say exactly what this "energy" actually *is*. Similarly, space, time, gravity, and light are descriptive constructs, but in a basic epistemological sense we do not actually "know" what these are.

As Einstein admitted: "Science is the attempt to make the chaotic diversity of our sense-experience conform to a logically uniform system of thought."[99] Science is a powerful way to observe and understand our world, but it is not itself the world.

Today, even the most basic scientific understanding of morphogenesis – how organisms form and grow – conventionally understood as derived solely from genetic inheritance, is questioned by some scientists. British biologist Rupert Sheldrake suggests that morphogenesis of organisms cannot be fully explained by reductionist genetics, and that nature itself may have collective memory exerted as a "morphic field."[100] Sheldrake's controversial hypothesis of "formative causation" proposes that in addition to genetic programming, organisms (including embryonic development, instincts, and behaviors) are shaped by resonance within a "morphic field" of collective memory in the species and its habitat. The theory has also been invoked to help explain heredity, memory, psychology, migratory abilities, social behavior, cultural inheritance, evolution, and cosmic evolution. At the very least, such thinking helps to underscore the current limitations of human knowledge.

> ***the Earth is / speaking to me in a language / I do not / yet / understand.***
>
> MARYBETH HOLLEMAN, POET, 2016[101]

There is a lot we simply do not, and perhaps cannot, know. Human knowledge, mediated by our limited 3-pound hominid brains, may always be subjective and imperfect. And it seems perfectly true that the more we know, the more we know that we don't know. The full reality of our world may always remain out of reach to us. Therein lies the enduring, sublime mystery of our world.

And faced with the findings of modern science, some speculate that it is astronomically improbable that the universe and life evolved by chance alone, and as physicist Paul Davies suggests: "a hidden principle seems to be at work organizing the cosmos in a coherent way."[102] Some invoke this as evidence for creationism by "God," while others as evidence that science doesn't yet, and may never, fully understand all of this. Perhaps the greatest impact of this sort of thinking is that even scientists are now forced

to marvel in amazement at, as Theodore Roszak says: "the extraordinary combination of factors that lie at the basis of physical reality - and to ask, quite candidly, if these should be regarded as 'coincidences'."[103] Some suggest that the universe, and life within it, may have somehow actually "wanted" to form. Perhaps that is a suggestion best left to debate by philosophers and theologians.

> *Instead of an intellectual search, there was suddenly a very different gut feeling that something was different. It occurred when looking at Earth and seeing this blue-and-white planet floating there, and knowing it was orbiting the Sun, seeing that Sun, seeing it set in the background of the very deep black and velvety cosmos, seeing – rather, knowing for sure – that there was a purposefulness of flow, of energy, of time, of space in the cosmos – that it was beyond man's rational ability to understand, that suddenly there was a non-rational way of understanding that had been beyond my previous experience. There seems to be more to the universe than random, chaotic, purposeless movement of a collection of molecular particles. On the return trip home, gazing through 240,000 miles of space toward the stars and the planet from which I had come, I suddenly experienced the universe as intelligent, loving, harmonious.*
>
> EDGAR MITCHELL, APOLLO 14 ASTRONAUT, REFLECTING ON HIS RETURN FLIGHT FROM THE MOON, 1971[104]

Science and religion seem to agree on at least one fundamental point: that our very existence remains an amazing, incomprehensible mystery. Religion explains the mystery of reality by invoking omnipotent deities, while science continues to explore testable scientific explanations for our existence. Either way, our existence is a marvelous mystery that we should not take for granted.

> *They should have put together an Apollo crew of a philosopher, a priest, and a poet.*
>
> MICHAEL COLLINS, APOLLO 11 ASTRONAUT, 1969[105]

We, and our world, are forever changing. Every second of every day, the molecular and physical composition and structure of our bodies changes imperceptibly as new molecules and particles flow in and out; our cells and tissues continue to grow, age, decay; our brains process new information, we learn and we forget. In a physical sense, we are continually becoming a new organism.

On a larger scale, Earth's geology and biosphere continue to change and evolve. Tectonic plates continue to move; mountains grow; mountains erode; Earth's rotation continually slows, and our rotational axis wobbles over millennia; cosmic dust falls to Earth; coral reefs and forests grow, change, and decay; new species evolve, others go extinct; atmospheric and ocean chemistry change; millions of living beings are born and die every second of every day. Our sun continues to use its hydrogen fuel, and radiative output increases slowly, yet continually, every second. The solar system continues to revolve around the center of the Milky Way galaxy at 514,000 mph, completing one "Cosmic Year" (one revolution) every 250 million years.[106] And as our home Milky Way galaxy streams (along with the Local Group of galaxies) toward the massive Virgo supercluster, our galaxy, solar system, and Earth continually occupy new regions of space.

Every second of every day each of us is a slightly new being, in a slightly new world, traveling into a new region of space where we have never been before and will never be again. Who knows what lies ahead for us in the next moment of space-time?

What we do know is that Earth has not always existed, and will not always exist. As with us, Earth is mortal. But we are here now, at this precise point in space-time, along with the several million other species and trillions of individual living beings with which we share this lovely planet, traveling together into an unknown future that, if we respond accordingly, could last for hundreds of millions of years.

Without doubt, our living, wet, warm, blue-green Earth is a "grand oasis in the vastness of space…a sparkling blue and white jewel…the only home we've ever known." ●

III

PARADISE LOST:

Global Ecological Collapse

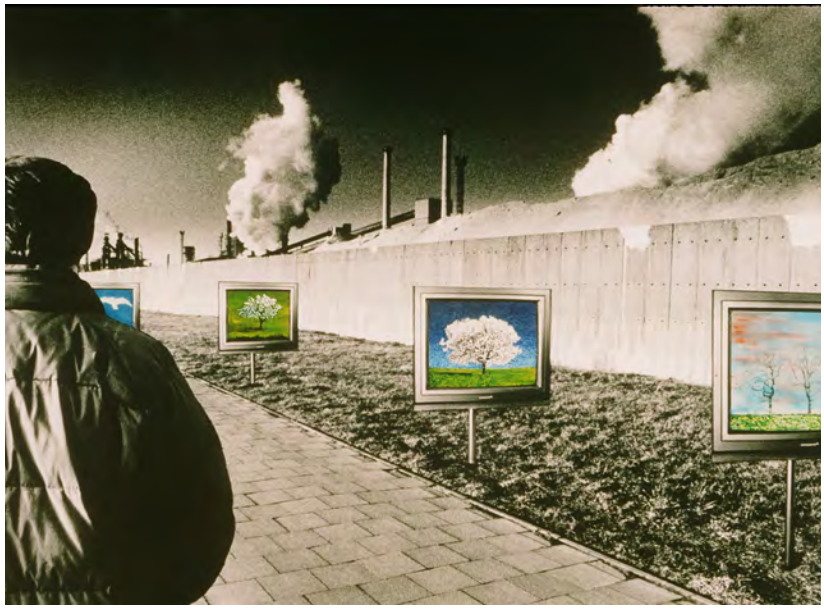
As a species we are now on trial to see whether rationality was an advance or a terrible mistake.

BILL MCKIBBEN, ENVIRONMENTAL JOURNALIST[107]

Ironically, this remarkable human brain/mind, millions of years in the making and capable of such beauty, compassion, and creativity, is also now responsible for the unprecedented destruction of the very life support systems of Earth. Perhaps the human brain/mind has yet to evolve the ability to self-regulate. No comets, no asteroids, just this self-reflective mind that was set forth long ago. We have become greedy monkeys on a wet, warm, blue-green planet. It is now clear that *H. sapiens* has become the most consumptive, wasteful, self-destructive organism to evolve in the 4 billion year history of life on Earth, and the entire biosphere is suffering for it.

A central question of our time is whether human civilization will evolve to ecological sustainability, or collapse? Anthropological studies have concluded that historic societal collapses (e.g., Sumerians, Anasazi, Maya, Greenland Norse, Easter Island) derived from five main causes: environmental damage from deforestation, land/soil degradation, and overharvest of resources; hostile neighbors; isolation from friendly trade partners; climate change; and failure to respond to environmental degradation.[108] The last one – failure to respond to known environmental threats – was a central factor in all these collapses.

These studies point to three consistent precursors of societal collapse: a drop in life expectancy, increased hunger, and failed cooperative governance. Globally, we see all three today. For instance, life expectancy in 20 sub-Saharan countries in Africa is now just 52 years, and in some countries as low as 42 years; the total number of chronically hungry people has risen to over 1 billion; there are now 60 fragile or failed states; and cooperative international governance is, with few exceptions, in chaos.



Of course, the current collapse will not be local as those historically have been, but global.

> *Civilizations die by suicide, not by murder.*
>
> ARNOLD J. TOYNBEE, HISTORIAN, 1961[109]

A recent NASA-sponsored study warns that modern industrial civilization may collapse in coming decades due to resource depletion and a growing unequal distribution of wealth. The authors write that:

> *The fall of the Roman Empire, and the equally (if not more) advanced Han, Mauryan, and Gupta Empires, as well as so many advanced Mesopotamian Empires, are all testimony to the fact that advanced, sophisticated, complex, and creative civilizations can be both fragile and impermanent.*
>
> NATIONAL SOCIO-ENVIRONMENTAL SYNTHESIS CENTER, 2014[110]

Fragile and impermanent, indeed. Since the publication of Rachel Carson's *Silent Spring* in 1962, people have worried about the long-term environmental effects of our industrial civilization. The first Earth Day in 1970 catalyzed a hopeful emergence of environmental policies in the U.S. — the National Environmental Policy Act, Endangered Species Act, Clean Water Act, Clean Air Act, and establishment of the U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, and White House Council on Environmental Quality. Financial aid flowed to developing countries in an attempt to help stabilize world population, the U.S. and Russia significantly reduced their nuclear weapons arsenals, and the United Nations agreed to many security and environmental treaties. The world developed a reasonable expectation that governments would rise to meet the global environmental and security crisis, and all would be well.

But today, 50 years later, this optimism has faded. We are worried, and we should be. The good news is that we can still turn this around, but time is running out. As discussed in Section IV, these are all human-caused problems, and fortunately, we know precisely how to solve them.

> *The view of the Earth from the Moon fascinated me - a small disk, 240,000 miles away. . . Raging nationalistic interests, famines, wars, and pestilence don't show from that distance.*
>
> FRANK BORMAN, APOLLO 8 ASTRONAUT, 1968[111]

In a nutshell, the problem is that the expanding human population and the rapidly rising rate of resource consumption and waste generation are overwhelming the planet's finite ecosystems. These reinforcing drivers have led to the loss of half the world's forests and wetlands; appropriation of a quarter of the total daily land plant production and half the world's available freshwater; thousands of species extinctions; runaway climate change; water and air pollution in every corner of the world; growing desertification; food and water shortages; severe economic inequality; and mounting global insecurity. When agriculture began, the total weight of all humans

and livestock represented an estimated 0.1% of the total weight of terrestrial vertebrate life on Earth, but today humans and livestock represent over 98% of all terrestrial mammalian biomass on Earth.[112] This is an extraordinary conversion of the biosphere.

Left uncorrected, this trajectory will with certainty lead to catastrophe, and soon. Governments everywhere have been fundamentally dishonest about this existential threat, and are failing their singular responsibility of securing the present and future welfare of their constituents.

For the past several decades, humanity has been accruing an ecological debt that is ignored in today's conventional economics. Such debt has traditionally been considered an "externality," but is now coming due. Many scientific syntheses conclude that the biosphere has been in serious decline since 1950, and that the rate of ecological decline has accelerated along with global economic expansion, mostly just since the end of World War II in 1945. Some scientists believe that a world population of roughly 2 billion people could live in relative prosperity if using only half the current per capita resource use today in the U.S. But these studies conclude that the current global population (7.7 billion), all living at modest standards of consumption, would need the resources of several more Earth-like planets.[113]

We are now a global civilization in collapse, but unlike other local societies before, we know the threat, how to resolve it, and yet still we fail to act to save our collective future. As well, there is nowhere else to which we can migrate to escape our destroyed home habitat.

The first Earth Day in 1970 catalyzed a hopeful emergence of environmental policies. People were optimistic that governments would rise to meet the global environmental crisis. Fifty years later, this optimism has faded.

Underlying Causes of Environmental Decline

The underlying causes of global environmental decline are complex and somewhat intractable, but include the following:

Human Nature - After 200,000 years of evolution, *H. sapiens* still has a rather primitive psychological nature that contributes to environmental degradation. As nature writer Wes Jackson has said: "We were all hard-wired during the upper Paleolithic, yet we are trying to behave in the modern world." The deep-seated, ancient psychology of human nature can be competitive, selfish, greedy, corrupt, domineering, and tribal, most of which may have been adaptive at the dawn of our species but is evolutionarily suicidal today.

> *What's most natural to us, just as to any living creature, is to seek to survive and reproduce. And for that purpose, we assert ourselves — relentlessly, unwittingly, savagely — against others: We push them aside, overstep them, overthrow them, even crush them if necessary. Behind the smiling facade of human civilization, there is at work the same blind drive toward self-assertion that we find in the animal realm.*
>
> COSTICA BRADATAN, PROFESSOR, 2019[114]

Corruption in today's political economy, a significant driver of environmental destruction, is a direct result of these deeply rooted psychological patterns. This ancient, tribal, territorial impulse can still be seen today in proxy as sporting events such as football, basketball, soccer, and hockey, where one troop of primates guards its home territory, while launching hostile incursions into the territory of adversaries. As well, our psychological desire for immediate gratification, while ignoring long-term consequences, plays a significant role in global environmental decline.

> *In trials of choice, people often favor immediate, smaller rewards over later, larger rewards. In the real world, indeed, we can be seduced by the quick gratification of smoking, overindulgence or a sedentary lifestyle, despite our good intentions. Such 'delay discounting' is associated with impulsive choices, even when at variance with our long-term interests. Extinction, then, is as much psychological as biological. It represents the global outcome of poor human choices — a tyranny of small decisions.*
>
> JAMES SCHAEFER, PROFESSOR, 2019[115]

The question remains as to whether modern humanity can now transcend its Paleolithic programming to save itself and the biosphere.

Desacralized Nature – As historian Arnold Toynbee noted: "We cannot exploit what we worship."[116] After our long animist history in which all of nature was revered – animals, plants, rivers, forests, mountains, and the weather - the development of monotheism (worship of a single, omnipotent god above) essentially granted humankind "dominion" over the natural world, dispensed with the sense of commonality with nature, and provided for the moral necessity of man's manipulation and control over the natural world. As Eugene Linden wrote: "Should the modern equivalent of the Book of Genesis be introduced into the U.S. Senate, it would be immediately dismissed as a partisan ploy by the business lobby."[117] Throughout history, animism and reverence for nature stood in the way

of commercial exploitation of the natural world, and were ultimately subverted in favor of a monotheistic god and heaven above, granting license for industrial exploitation of the biosphere.

Failures of Market Economics – Market capitalism, poorly regulated, is a dominant driver of environmental decline. Market forces fail to anticipate and plan for the future, cannot correct injustice, cannot account for "externalities" (e.g., non-market environmental damage), cannot restrain unsustainable growth, cannot provide quality of life, and above all cannot adequately value ecosystems, services, or present and future ecological damage. As Lester Brown said: "Socialism failed because it didn't tell the economic truth, capitalism may fail because it doesn't tell the ecological truth."[118] And as Vladimir Lenin mused regarding the failure of capitalism: "A capitalist will sell you on Tuesday the rope you will hang him with on Saturday."

Failures of Government - Governmental institutions that manage the world today are generally inefficient, highly fragmented, underfunded, lack vision and motivation, and are generally coopted by narrow, short-term corporate interests to protect status quo power structures.

> *A phenomenon noticeable throughout history regardless of place or period is the pursuit by governments of policies contrary to their own interests. Mankind, it seems, makes a poorer performance of government than of almost any other human activity. In this sphere, wisdom, which may be defined as the exercise of judgment acting on experience, common sense and available information, is less operative and more frustrated than it should be. Why do holders of high office so often act contrary to the way reason points and enlightened self-interest suggests? Why does intelligent mental process seem so often not to function?*
>
> BARBARA W. TUCHMAN, HISTORIAN, 1984[119]

Increasingly, government has become a facilitator for the short-term interests of corporations rather than public wellbeing. Economist Lester Milbraith notes

The central question of our time is whether human civilization will evolve to ecological sustainability or collapse. This question will likely be answered this decade.

that corporations are the principal instruments of the "patriarchal dominator society," and are themselves controlled by a small, patriarchal elite in sole pursuit of money, power, domination, and control.[120] As discussed in Section IV, effective government is the critical key to reversing environmental and social decline.

> *You develop an instant global consciousness, a people orientation, an intense dissatisfaction with the state of the world, and a compulsion to do something about it. From out there on the moon, international politics look so petty. You want to grab a politician by the scruff of the neck and drag him a quarter of a million miles out and say, 'Look at that you son of a bitch.'*
>
> EDGAR MITCHELL, APOLLO 14 ASTRONAUT[121]

ENVIRONMENTAL DECLINE

Population

Lack of attention to global population will be the ultimate global blunder.

WERNER FORNOS, POPULATION INSTITUTE[122]

Population growth amplifies all other human impacts on the global environment. As the U.N.'s 2019 GEO 6 concludes: "Other things being equal, a larger population means higher consumption, which in the long run puts increased pressure on natural resources."[123]

From the dawn of modern *H. sapiens* 50,000 years ago to the beginning of the Agricultural Revolution 8,000 years ago, global population had increased to only about 5 million people. By the beginning of the Industrial Revolution in 1800, world population reached 1 billion. The total number of people that have lived since the dawn of our species is estimated to be about 110 billion.[124]

In the last century, world population increased four-fold (from 1.5 billion to 6 billion); it is now at 7.7 billion, and continuing to rise. World population increases on average 82 million people each year (220,000 people a day), and is expected to reach 10 billion by 2050, with the additional 2.3 billion coming almost exclusively from developing countries (mostly in Africa and Asia). The U.N. projects that world population may level off at 11 billion by the end of this century, but if fertility does not decline as hoped, world population could reach 16.5 billion by then (more than twice today's population).[125] The U.N.'s GEO 6 concludes that: "High inequality and population growth are also inextricably linked."

Demographic megatrends today include continued rapid population growth, ageing, urbanization, and migration. Although several developed nations have reached or are approaching population stability, many developing nations have not.

World population increased four-fold last century, from 1.5 billion to 6 billion. Today it is 7.7 billion and is expected to exceed 11 billion by 2100.

World population increases by 220,000 each day, 82 million each year.

Fertility rates average only 1.6 children per woman in Europe, but average 4.2 per woman in Africa. Average global fertility has declined from 4.5 children per woman in 1970 to 2.5 per woman today, and the average lifespan has risen from 65 in 1990 to 70 today. And world population *growth rate* has declined in recent decades from a high of 2.2% per year to now about 1% per year.[126] But these encouraging global trends obscure some troubling regional realities and megatrends.

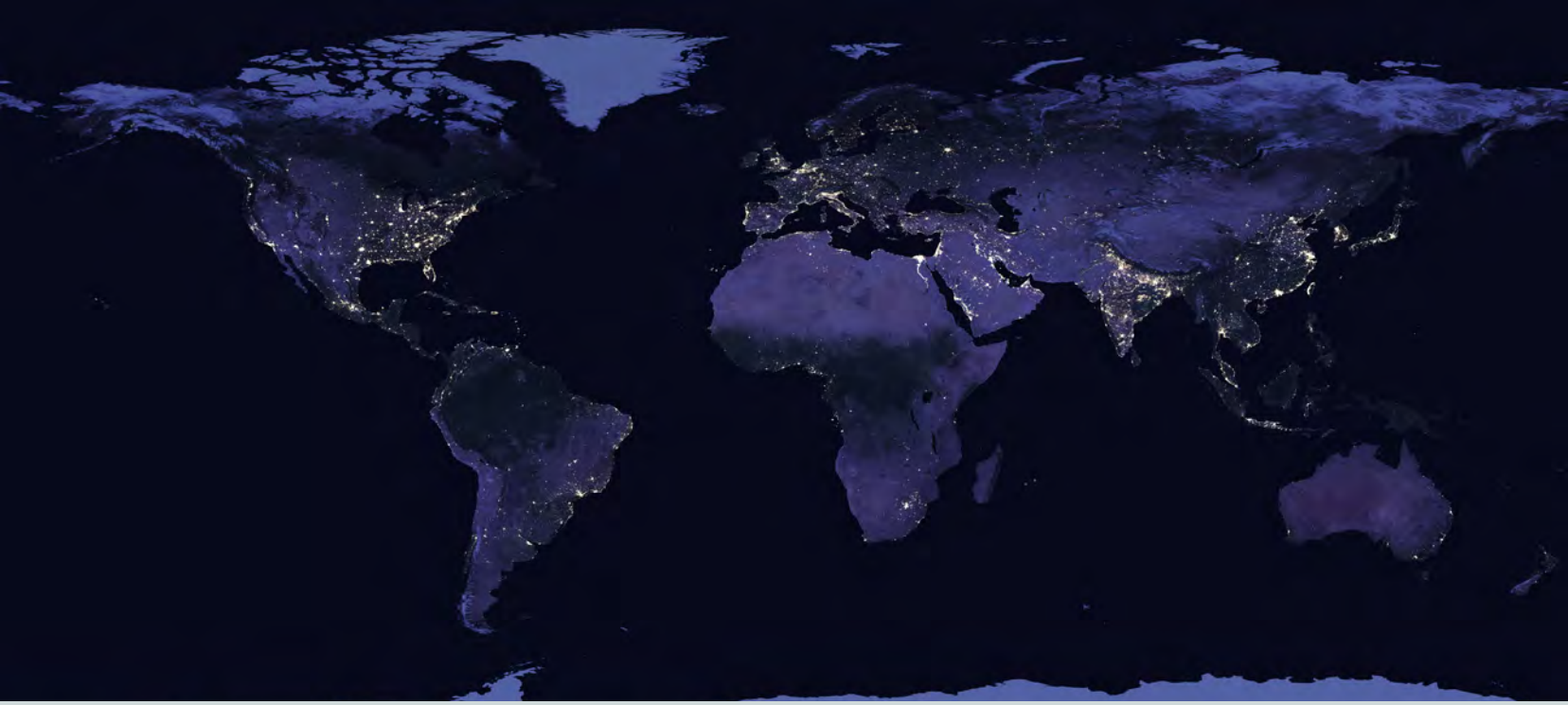
For instance, the populations of Africa, where over 60% of its 1.2 billion people are under the age of 25, and South Asia, now with over 1.5 billion people, are expected to more than double by 2050. Some countries with the greatest biodiversity, such as Indonesia and Brazil, still have unsustainably high fertility rates. And, the largest generation of young people in history, over 1.8 billion aged 10-24, is now reaching reproductive age.[127]

Population stabilization programs desperately need financial support, but future support for these programs is in jeopardy. In developing countries where fertility rates are still quite high, family planning, health care, and contraceptives are not widely available; poverty and lack of economic opportunity is widespread; illiteracy rates are high; and there is significant discrimination and violence against women. Illiteracy reinforces lack of economic opportunity, which reinforces poverty, which reinforces unsustainable population growth – a vicious circle.

Despite the clear need to stabilize world population, most religions continue to oppose contraception, as they suggest it would lead to "sinful" promiscuity. In some cultures (e.g., India), preference for male over female children leads parents to continue having children until they have a male child, further increasing fertility rates.[128] This age-old cultural preference has led to over 20 million "unwanted girls" in India and China, and increases female infanticide. High population growth rates also fuel conflict over territory and resources. Despite the direct link between population growth and environmental decline, the U.N. continues to refuse endorsing population stabilization (zero population growth) as a goal.

Some studies estimate that the Earth could sustainably support between 1-2 billion people in a healthy, prosperous society.[129] No scientific studies have concluded that Earth can sustainably support 11 billion people, even with modest levels of consumption.

> *Does human society want 10–15 billion humans living in poverty and malnourishment, or 1–2 billion living with abundant resources and a quality environment?*
>
> DAVID PIMENTEL, PROFESSOR, 1999[130]



Earth at Night. Studies estimate that the Earth could sustainably support 2 billion people, but no studies conclude that Earth can sustainably support 11 billion people.

Resource Consumption and Depletion

In addition to increasing population, the rate of material and energy consumption (and its corresponding waste/pollution) has increased dramatically in recent decades. Just since 1950, we have consumed more goods and services globally than all previous generations combined.[131] The U.N. reports that our global material footprint (the amount of materials used by humanity) has more than doubled in the last 30 years, and is "rapidly growing, outpacing population and economic growth."[132]

The Global Footprint Network (GFN) calculates that humanity today consumes about 1.75 times the natural resources that Earth can sustainably provide, and that it takes Earth one year and 8 months to regenerate what we use each year.[133] The GFN calculates Earth Overshoot Day each year, as the date by which we have used more from nature than can be renewed. Earth Overshoot Day has advanced more than two months over the past 20 years, and in 2019, fell on July 29 - the earliest ever.

As noted by UNEP's Global Resources Outlook 2019:

- Global resource use has more than tripled since 1970 to reach 92 billion tons in 2017;
- Global material productivity has not improved in the last 20 years;
- High-income countries continue to outsource resource-intensive production;
- Resource extraction and processing cause over 90 percent of global biodiversity loss and water stress, and more than half of global climate change impacts;
- Environmental impacts of material consumption are 3 to 6 times greater in high-income countries than in low-income countries;

- Without action, resource use will more than double from current levels (92 billion tons per year) to 190 billion tons by 2060. Related impacts would exceed planetary boundaries.

U.N. GLOBAL RESOURCES OUTLOOK, 2019[134]

It is astonishing that a species with a relatively small global biomass (dry weight) of only about 125 million tons (*H. sapiens*), is now extracting and using 92 billion tons of raw resources from the Earth each year, over 700 times its own weight.

The "Gross World Product" (global GDP) has increased over ten-fold since 1950, from $6 trillion in 1950 to over $88 trillion today. Global GDP has a direct, if non-linear, relationship to unsustainable resource consumption and environmental impact. Current resource consumption is estimated to be over 50% beyond Earth's carrying capacity.[135] While economists worry about national fiscal debt, they ignore the fact that every year we go deeper into ecological debt.

Since 1950, the worldwide consumption of energy, meat, steel, timber, and copper has more than doubled; freshwater use has increased three-fold; fossil fuel use, car ownership, fish catch and paper consumption have increased five-fold; and air travel has increased 100-fold.[136] As resource production and consumption is such big business, many of the resources used are simply wasted to increase demand for increased production. It is a vicious produce-waste-produce cycle.

Consumption rates and linear activities (extract-make-use-dispose) have increased resource exploitation beyond the recovery ability of ecological systems, with harmful consequences at all levels from the local to the global.

U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[137]

Conspicuous consumption has become a homogenizing social force in much of the developed world. Today there are over 1.6 billion televisions in the world, with over 4 billion viewers. World advertising expenditures, seeking

to increase consumption by projecting a romanticized view of consumer life, increase approximately 5% each year, and are now about $2 trillion a year.[138]

Consumption itself has become an end goal, rather than the means to happiness, and it has defined our age – "you are what you own," and "net worth equals self-worth." Shopping has become a primary cultural activity in the consumer world. Shopping malls, and the cars and highways to drive to them, have replaced family-owned corner stores, and neighborhoods have atrophied.[139]

Some of the discontentment in the affluent Western world derives from a dysfunctional relationship with money, an emotional desire to own and consume more than is necessary. Accumulation of excessive wealth among the affluent is well established as a driver of resource consumption and depletion.

For the most part, people need money to spend on things that we've spent billions persuading ourselves we need.

PHILIP SLATER, ECONOMIST, 1980[140]

As Slater notes, the affluent in industrial societies often convince themselves they need unnecessary employment so that they will have unnecessary money to buy unnecessary things. This is of course also a significant contributor to resource consumption and depletion.

And in the developing world, there is a ticking "aspiration bomb," in which people exposed through advertising to the many luxuries and indulgences of the affluent world also want these amenities. China is rapidly becoming a consumer society.[141] For instance, with virtually

Our global material footprint (the amount of materials used by humanity) has more than doubled in the last 30 years and is "outpacing population and economic growth."

no private cars in 1980, China today has over 300 million cars, now replacing bicycles as a main form of transport. Worldwide government subsidies to consumerism exceed $1 trillion a year, much of which encourages more single family homes, more home appliances, more cars, more roads, more sprawl, more energy use, and more unsustainable consumption.

The unequal distribution of this energy and material consumption adds significant environmental, social, economic, and security problems. While the developed world basks in false economic prosperity, if real costs are calculated, sustainable economic welfare has been in decline since the 1970s.[142]

There is simply no way that Earth's ecosystems can continue to support an expansion in human population coupled with increasing material and energy consumption and waste of such magnitude. This is, after all, a finite planet. Today's resource consumption, indulgence and gluttony are stealing resources from future generations.

Extinction: "The Great Dying"

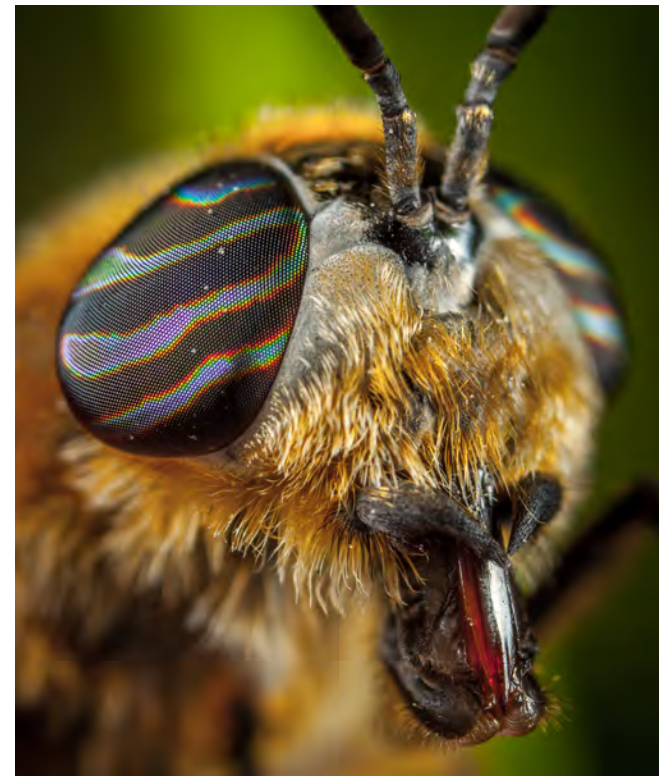
Biodiversity is like a library of unread books, and we haven't even finished the first chapter...and we're losing the species around us before we can even turn the next page.

E. O. WILSON, BIOLOGIST, 2002[143]

As discussed in Section II, since the Cambrian evolutionary radiation began 540 million years ago, five mass extinction events have occurred in which over 75% of all species died off. Today we are in the 6th mass extinction - the Anthropocene extinction – caused exclusively by humans.

The current Anthropocene extinction is considered by many ecologists to be the most important environmental issue of our day, as species loss is irreversible. The numbers are simply staggering. Ecologists fear we may be losing between 100-200 species every day (most of which have yet to be identified), and 20 years ago estimated that we had lost perhaps 600,000 species since the "biotic holocaust" began around 1950.[144] At the mid-range estimate of species loss rate today, the biosphere has already lost over 1 million species in the last 50 years. And a recently released 3-year global study by the U.N. Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) estimates that "another 1 million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history."[145] The U.N. report confirms that the Anthropocene extinction is accelerating.

The pre-human (baseline) extinction rate is estimated to have been from 1-10 species per million species



Today's species extinction rate is between 100 to 1000 times the pre-human extinction rate.

Ecologists fear we may be losing between 100 to 200 species every day (most of which have yet to be identified) and that we may have already lost over one million species since the "biotic holocaust" began 50 years ago.

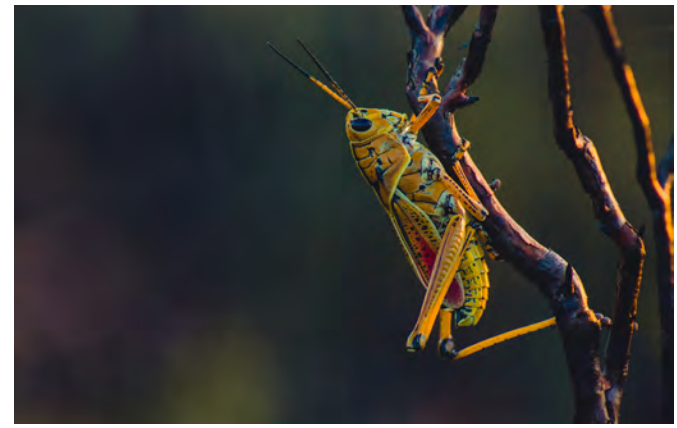
every year (thus with a total of 10 million species, the pre-human extinction rate would have been 10-100 per year).[146]

Since the evolution of *H. sapiens*, four principal waves of human-induced extinction have occurred. The first human-induced extinction wave occurred as early man migrated out of Africa into the Middle East and Australasia, roughly 40,000 years ago. The next occurred as the last ice age began to recede 12,000 years ago, and is known as the Late Pleistocene megafauna extinction. As humans spread into previously ice-covered regions in the northern hemisphere, overhunting exterminated over half of all megafauna species (those weighing over 100 pounds). Many mammals were eliminated, including the cave bear, wooly mammoth, mastodon, dire wolf, North American camel, step bison, giant ground sloths, and saber-toothed cat. The warming climate may have contributed to these extinctions, but as most of the species had survived several interglacial periods before, this seems unlikely. Overkill by early man is the most plausible explanation.[147]

The third wave of modern extinction began approximately 2,000 years ago, as humans continued to spread and colonize the planet. Particularly notable was the loss of birds in the Pacific islands (e.g., the loss of the flightless dodo in Mauritius) caused by newly arrived humans. Professor E. O. Wilson concludes that this wave of extinctions claimed "close to one thousand species," and that "some 10% of the bird species on Earth were wiped out during a single episode of colonization by relatively small groups of people."[148]

Yet these historic human-caused extinctions are now dwarfed by the fourth-wave, the current Anthropocene mass extinction. This mass extinction began about 1950 with the rapid expansion of human population, energy use, habitat conversion, technology and resource use. Estimates of today's extinction rate vary considerably, due to uncertainties involved in the loss of species yet to be identified. But most estimates agree that today's extinction rate is between 100-1000 times the natural background (pre-human) rate.

Of the hundreds of identified species to have gone extinct in recent centuries, some of the better known include the passenger pigeon in North America (once with 5 billion individuals, the most numerous bird in the world), the flightless dodo of Mauritius, Steller's Sea Cow (Aleutian Islands), Great Auk (North Atlantic), Carolina Parakeet (eastern U.S.), Thylacine ("Tasmanian tiger"), Japanese Sea Lion, Caribbean Gray Whale, and the Golden Toad



(Costa Rica). Just in the past decade, known extinctions include the Alaotra Grebe of Madagascar, Pinta Tortoise of the Galapagos, Formosan Clouded Leopard of Taiwan, Caribbean Monk Seal, Liverpool Pigeon of Tahiti, West African Black Rhinoceros, Christmas Island Pipistrelle (a tiny bat), Madagascar Hippopotamus, Japanese River Otter, and Yangtze River Dolphin.[149] These unique species are now gone forever. But scientists agree that the vast majority of extinctions today are species that are not yet identified – the "silent extinction."

Complex models, based upon quantitative species-area relationships, are used to estimate extinction totals, including the yet to be identified species. The Millennium Ecosystem Assessment (conducted by hundreds of experts) estimated the extinction rate today at 8,700 per year, or about 24 per day.[150] The U.N. Convention on Biological Diversity estimates that: "Every day, up to 150 species are lost."[151] The U.N. Environment Program (UNEP) has estimated today's extinction rate at 100–200 species per day, or some 36,500–73,000 species per year.[152] Other analyses estimate today's extinction rate at 100–1,000 per million species per year. Thus with a total of 10 million species on Earth, this would predict a total annual extinction rate of 1,000–10,000 species/year.[153]

Despite the uncertainties in the exact number, we are almost certainly losing thousands of species per year, most of which have yet to be identified, and at a rate

hundreds of times the historic background rate. And we are losing not just "charismatic megafauna," and not just from islands or rainforests. It is occurring everywhere, and to all phyla of organisms. And we are all forever poorer.[154]

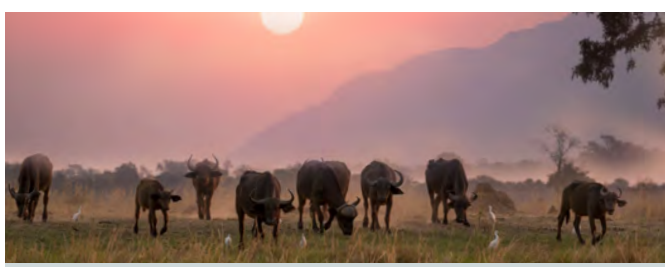
Perhaps half of all terrestrial species on Earth are in tropical rainforests, and scientists estimate that for every plant species that goes extinct there, perhaps another 10-30 species are lost due to the specialized feeding habits of herbivores in these habitats.[155]

The 65,400 vertebrate species known today offer a conspicuous measure with which to gauge the present extinction crisis, as over a quarter of vertebrate species are considered to be presently threatened, as follows[156]:

Class	Species	Threatened
Mammals	5,700	25%
Birds	11,000	14%
Fish	32,000	34%
Reptiles	10,000	34%
Amphibians	6,700	41%
Total Vertebrates	**65,400**	**30%**

Half of the 233 known primate species are currently at risk of extinction.

The critically endangered species with less than 100 individuals, what E. O. Wilson calls the "Hundred Heartbeat Club," includes the Philippine Eagle, Hawaiian Crow, Spitz Macaw, Vancouver Island Marmot, Java Rhino, Hainan Gibbon, Texas Pipefish, Japanese Ibis, Sea of Cortes Vaquita (a dolphin), and the North Pacific Right Whale.[157] Others that are perilously close to this threshold include the Sumatra Rhino, Sumatra Orangutan, Golden Bamboo Lemur, Mediterranean Monk Seal, and the Philippine Crocodile.



If trends continue, half of all species on Earth may be extinct by 2050.

> ***The average abundance of native species in most major land-based habitats has fallen by at least 20%, mostly since 1900. More than 40% of amphibian species, almost 33% of reef-forming corals, and more than a third of all marine mammals are threatened.***
>
> U.N. IPBES GLOBAL ASSESSMENT, 2019[158]

If present trends continue, half of all species on Earth may be extinct by 2050.

Beyond species extinction, a recent scientific analysis of 18,000 populations of 3,800 species estimated that just since 1970, the *population size* (total number) of vertebrates on Earth has declined by an astonishing 60%, and that by 2020 this will increase to 68%.[159] This stunning conclusion deserves repeating: the number of vertebrates on Earth has dropped by two-thirds in the past 50 years. This is a phenomenal decline. As well, global seabird populations have declined by 70% since 1950 due to overfishing of their prey, plastic debris, incidental take by fishing gear, rats on nesting habitat, pollution, and climate change.[160]

In addition, recent studies have shown that the body mass of individual birds and mammals has declined due to habitat degradation, overhunting, intensive agriculture and climate change.[161] According to this study, overall body mass of mammals has declined by an estimated 14% over the last 130,000 years, and this "downsizing" is expected to accelerate over this century.

Another stark measure of the Anthropocene homogenization of the biosphere is the relative biomass of humans and livestock compared to other land mammals. A 2012 study estimates that the biomass (dry weight) of all humans on Earth today - 125 million tons - is more than 10 times the biomass of all wild terrestrial mammals - 10 million tons.[162] The biomass (dry weight) of over 4 billion livestock animals kept by humans (cattle, water buffalo, pigs, and goats) is estimated at 300 million tons, more than twice the biomass of all wild land mammals and humans combined. Astonishingly, the combined dry weight of all humans and livestock - 425 million tons – now represents over 98% of the total land mammal biomass of the biosphere, with wildlife at only 10 million tons, or 2%.[163]

For plants and invertebrates the situation is even worse. The World Conservation Union's (IUCN) "Red List" evaluated over 40,000 species of invertebrates and plants, and listed 40% as currently threatened (vulnerable, endangered, critically endangered).[164] Plants are only able to relocate slowly, via seed dispersal, and thus are more vulnerable to localized habitat loss. Of the 12,914 plant species evaluated by IUCN (out of 400,000 plant species worldwide), 68% are estimated to be at risk of extinction.[165] Of the 9,526 invertebrate species evaluated, about 30% were found to be at risk of extinction.

Further, it is estimated that half of the *number* of invertebrates (populations) has been lost in recent decades.[166] One recent study found that global insect biomass is declining by a stunning 2.5% per year, that we have lost 41% of global insect numbers just in the last decade, and that more than 40% of insect species may become extinct in the next few decades due primarily to habitat loss from agriculture and urbanization, pesticides and fertilizers, pathogens, invasive species, and climate change.[167] This loss of insect biodiversity and biomass is having catastrophic impact on terrestrial ecosystems.

> *At present, 42 percent of terrestrial vertebrates, 34 percent of freshwater invertebrates, and 25 percent of marine invertebrates are considered at risk of extinction.*
>
> U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[168]

And, within the Earth's 8-10 million or so species there could exist on the order of some 2 billion genetically distinct populations, which are likely being lost by the thousands every day.[169] The biosphere is being simplified and homogenized, and our Home Planet is rapidly becoming an empty, lonely, dead zone.

The main causes for species, population, and genetic extinction are habitat loss (e.g., deforestation, dam building, agriculture), overharvest, climate change, and invasive species.[170] The most significant driver of the Anthropocene extinction is human-caused conversion, degradation, and loss of ecological habitat. But others are growing in significance as well. Illegal trade in wildlife, fisheries, and forest products - is currently valued at between $90 billion and $270 billion per year.[171] Environmental crime has increased dramatically in recent years, now eclipsing the value of all humanitarian aid to developing countries.[172] And invasive species are becoming an increasingly important driver of extinction.

> *The numbers of invasive alien species per country have risen by about 70% since 1970, across the 21 countries with detailed records.*
>
> U.N. IPBES GLOBAL ASSESSMENT, 2019[173]

Finally, a new worry for the future of biodiversity is the development of gene editing (splicing) technology, such as CRISPR (Clustered Regularly-Interspaced Short Palindromic Repeats), allowing scientists to create new treatments for diseases and new types of plants and animals to control unwanted organisms such as disease-bearing mosquitoes (that now kill 700,000 people each year). Scientists can now snip out a segment of DNA and replace it with another sequence, permanently altering the natural genome. As someone recently cautioned about CRISPR: "This innovation has been called the extinction machine because it allows us to intrude on natural selection to wipe out any undesirable species."[174] Comedian John Oliver stated: "It seems gene editing is going to eliminate all disease, or kill every last one of us."[175] Engineered mutations can be inadvertently transferred into other organisms, with no understanding or control of unintended consequences. While a moratorium on germline (multi-generational) mutations is in place in the U.S., such controls do not exist elsewhere, notably China.

> *We think we know what we're affecting if we manipulate one gene for that particular species. We think we know what we're affecting if we just affect one particular species in an ecosystem. The truth is we probably don't, and there's always some surprises.*
>
> GREG LICHOLAI, BIOTECHNOLOGIST, 2018[176]

Forests

Forests precede civilization and deserts follow.

FRANCOIS-RENE DE CHATEAUBRIAND, CIRCA 1802[177]

An enormous scientific literature confirms the direct link between global deforestation and the loss of biodiversity. This is one of the most thoroughly understood phenomena in all of science: lose forests - lose forest species. An estimated 80% of all terrestrial species on Earth are found in forests. For a species that evolved from forests and still depends on the ecological services of forests, *H. sapiens* is behaving in a peculiarly irrational, self-destructive manner by destroying them.

For the past several decades, scientists, indigenous peoples, governments, and non-governmental organizations (NGOs) have all called attention to the unprecedented crisis of global deforestation. The metrics are perfectly clear and disturbing:[178]

- Half of Earth's original forest cover is gone, and more than 30% of the remaining is degraded or fragmented, much of it converted in the past 50 years;
- Only 20% of the original forest cover on Earth remains today as large, relatively undisturbed primary, closed canopy, frontier forests (mostly in Brazil, Canada, and Russia), evenly divided between tropical and boreal regions;
- Half of the world's total frontier forest is currently threatened by human activity, mostly by logging, and mostly in tropical forests;
- An additional 15-30 million acres of forest are lost each year, mostly in the tropics;
- Forest loss accounts for 23% of global manmade CO^2 emissions, largely from burning and release of carbon into the atmosphere;
- 80% of the terrestrial species on Earth inhabit and depend upon the world's forests, and more than half of the threatened vertebrate species on Earth depend on forest ecosystems;
- Deforestation is the primary cause of the present mass-extinction;
- Some 1.6 billion people, including 70 million Indigenous Peoples, inhabit and depend upon world forests.

The Anthropocene destruction of world forests is driven by increasing demand for (and waste of) wood products; road building; firewood gathering; clearing for agriculture (soybeans, palm oil, cattle, rubber, and tree farms); climate change; settlement and urbanization; oil drilling; hydroelectric dams; wildfire; mining; corruption and illegal logging; perverse financial subsidies; and ineffective governance and trade policies.

Deforestation is a primary cause of the present mass extinction.

Half of Earth's original forest cover is gone, and more than 30% of the remaining is degraded or fragmented, much of it converted in the past 50 years.

Just since 1950, over 30% of all tropical forests have disappeared, and with them thousands of species have been lost. The Amazon rainforest is the largest rainforest on Earth (7.5 million km^2), holds over 200 billion tons of carbon, 20 percent of all available surface freshwater, perhaps half of the terrestrial biodiversity on Earth, and produces 20 percent of the oxygen in the atmosphere.

> *Unchecked development is placing the Amazon under threat, pushing deforestation rates to near record levels throughout the region.*
>
> LISA VISCIDI, INTER-AMERICAN DIALOGUE, 2019[179]

Rainforests of the Amazon and Indonesia have been extensively degraded in recent decades, and the rate of deforestation has recently increased dramatically. Fewer trees leads to less evapotranspiration and less rainfall, which in turn leads to even fewer trees. This vicious cycle may approach a "tipping point" at which tropical rainforest ecosystems collapse, transitioning to dry scrubland. Scientists now fear that in the next 20 years over 50% of Amazon rainforest will transition to scrubland due to drying, leading to even more forest loss from wildfires.[180] In 2019, newly elected Brazilian President Jair Bolsonaro declared that "the Amazon is open for business," leading to a dramatic increase in setting fires to clear forestlands for agriculture. As a result, wildfires across the Amazon basin increased substantially, increasing carbon emissions and loss of biodiversity.

Forests are being cleared for palm oil plantations.

An additional 15 to 30 million acres of forest are lost each year.

Cutting forests also increases the reflectivity (albedo) of the planet surface, releases large amounts of CO^2, reduces CO^2 absorption, damages water quality, and alters atmospheric circulation and hydrologic patterns that further exacerbate regional climate. Intact forests provide huge economic and public safety value in flood control alone, as witnessed in catastrophic floods along the deforested Yangtze Valley in China.

And the temperate forests, once covering most of Europe, China, the U.S., and parts of Canada, Australia, New Zealand, Chile, U.K., and Argentina, have been the most extensively altered, with less than 3% remaining today as intact, frontier forests. The loss of coastal temperate rainforests has caused extensive ecological damage along the northwest coast of North America.[181]

Alarmingly, the rate of tropical deforestation has increased significantly in recent years. In Brazil, despite decades of slowing deforestation prior to 2015, deforestation increased by 29% from 2015 to 2016, making it impossible for Brazil to meet its Paris climate commitments.[182] Clearing forests for palm oil production in Indonesia and Peru has increased as well.

Sadly, the vast majority of the world population has never even seen a truly natural, ecologically intact forest, and most may not even realize that they haven't. This detachment makes the challenge of forest conservation that much more difficult.

Rainforests have been extensively degraded, the rate of deforestation has increased, and they are now approaching a tipping-point of ecosystem collapse transitioning to dry scrubland.

Forest fire smoke over the Amazon.

Food and Agriculture

Many scientists conclude that agriculture represents the largest environmental impact of any human activity, and that it is *the* main driver of ecological degradation. Inefficient farming on an industrial scale causes enormous environmental damage. Agriculture currently uses over 50% of the habitable land of the planet, most of which (77%) is used for livestock; uses 70% of all available freshwater; and is responsible for 80% of global deforestation.[183] Agriculture, forest clearing, and other land use account for 21% - 37% of global greenhouse gas emissions, approximately 12 billion tons CO^2 equivalent, per year.[184] World agriculture currently receives over $300 billion in annual government subsidies, encouraging unsustainable monoculture practices, poor water management, deforestation, and overuse of chemical fertilizers. Crop production has increased over 3-fold just since 1970.[185]

With 80 million more people to feed each year, and billions more wanting to move up the food chain to consume more protein, food presents a pivotal challenge to future sustainability.[186] There is considerable concern regarding heat stress on crops, dropping water tables, soil erosion, drought, floods, and increased resistance of crop pests to pesticides.

Today 2 billion people are undernourished or hungry, and 2 billion are overnourished (overweight or obese), both with serious health and environmental effects.[187] Over 6 million people a year (17,000 a day), mostly children, die from malnutrition.[188] Millions of underweight infants are born each year to malnourished mothers, with long-term health and cognitive effects. And the number of undernourished people has increased substantially in recent years, mostly in Sub-Saharan Africa and South Asia.[189]

Agriculture currently uses over 50% of the habitable land of the planet, most of which is used for livestock. Agriculture uses 70% of all available freshwater and is responsible for 80% of global deforestation.

Food *production* and *distribution* remain the two greatest issues. The U.N. predicts that there will be a point soon at which the global food supply will not keep up with population growth and demand. Today, the U.N. lists over 80 countries that can't grow or buy enough food.[190] And the U.N. reports that 149 million children (22%) under age-five are stunted due to malnutrition.[191]

Yet each year from 25%-30% of all food produced globally, or about 1.3 billion tons, is lost or wasted, costing the world economy about $1 trillion annually, and contributing about 9% of total global greenhouse gas emissions.[192]

Humans currently get about half of their calories from grain (wheat, rice, corn), and grain production now (about 2.5 billion tons per year) cannot meet rising demand due to drought, irrigation water shortages, aquifer depletion, water diverted to cities, land and water used for livestock, and ethanol production.[193] This production/demand gap is particularly severe in China. Globally, grain prices are increasing, and many poor nations may not be able to afford to import enough, leading to increased political instability.[194]

The U.N. lists over 80 countries that can't grow or buy enough food and says that 149 million children under age five are stunted due to malnutrition.

Picking ants.

Meat production continues to rise, now over 320 million tons a year, more than a five-fold increase since 1950.[195] There are now about 1.5 billion cattle on Earth, with more biomass than all of humanity. Meat production consumes about 40% of all grain, while a billion people go hungry; uses a third of the land surface of the planet; and causes severe soil erosion, loss of forests, aquifer depletion, desertification, pesticide and fertilizer runoff, and significant emissions of methane – a potent greenhouse gas.

> *Animal agriculture is one of the largest contributors of human-made greenhouse gas emissions, deforestation, water pollution, and air pollution. Worldwide, meat and dairy production uses 83% of farmland and produces 60% of agriculture's greenhouse gas emissions, while providing just 18% of calories and 37% of protein.*
>
> J. POORE AND T. NEMECEK, ENVIRONMENTAL SCIENTISTS, 2018[196]

Meat production alone accounts for 20% of world greenhouse gas emissions, more than that from all the cars in the world.[197] And over 75% of the soy grown globally goes to feed livestock for meat production. Meat production has an exceptionally high embedded (or virtual) cost in water, deforestation, and energy, which is then "exported" to meat importing countries. The fires that destroy thousands of

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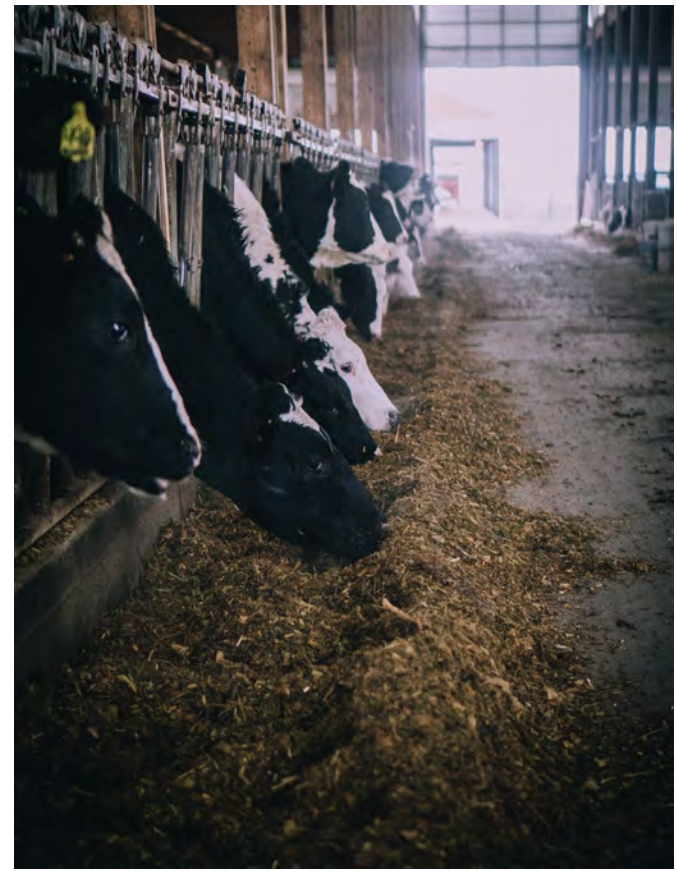


hectares of Amazonian and Indonesian rainforest every dry season are largely set to clear forestland for livestock agriculture. And the World Health Organization says that, due to overuse of antibiotics in livestock, antibiotic resistant diseases will be the main cause of human deaths by 2050.[198] While meat consumption is near saturation in the developed world, it is still growing in the developing world. China is now the world's largest meat producer and consumer.[199]

A 2018 study found that: "an area of land that could produce 100 grams of edible protein from plants could only produce 60 grams of edible protein from eggs, 50 grams of protein from chickens, 25 grams of protein from dairy, 10 grams of protein from pigs, and just 4 grams of protein from beef."[200]

Irrigated land area continues to rise, mostly in Asia. Over 70% of all water used by humans goes to irrigation, most of which is simply wasted through inefficient practices.[201] Agricultural water use has tripled in the last 50 years, while industrial use has increased six-fold. As a result, water tables are dropping in much of the world's farmlands, as much as 3 meters per year on the North China plain where much of China's grain harvest occurs. Excess irrigation also causes salinization through residual salts left after evaporation, degrading a significant amount of irrigated lands. Irrigation efficiency – the amount of water actually used by plants relative to water extracted – remains at less than 50% on average.[202]

And intensive use of toxic, synthetic pesticides and fertilizers in industrial agriculture is causing dramatic ecological impacts, including global insect declines and hundreds of anoxic oceanic dead zones offshore of major river deltas. A recent study documenting alarming global decline of insects due to industrial agriculture concluded:

> *Unless we change our ways of producing food, insects as a whole will go down the path of extinction in a few decades. The repercussions this will have for the planet's ecosystems are catastrophic to say the least.*
>
> FRANCISCO SANCHEZ-BAYO, 2019[203]

Another recent study estimates annual value of world crops at risk from loss of pollinator insects at $235 billion - $577 billion.[204]

The 2019 U.N. Global Environment Outlook predicts that: "Adequately feeding 10 billion people by 2050 will require an increase of 50 percent in food production."[205] This increase in food production will exert additional pressure on already overexploited terrestrial and aquatic ecosystems.

To feed 10 billion people by 2050, the U.N. says food production needs to increase by 50%, which will exert more stress on ecological habitat, soil, and climate.

Land Degradation and Desertification

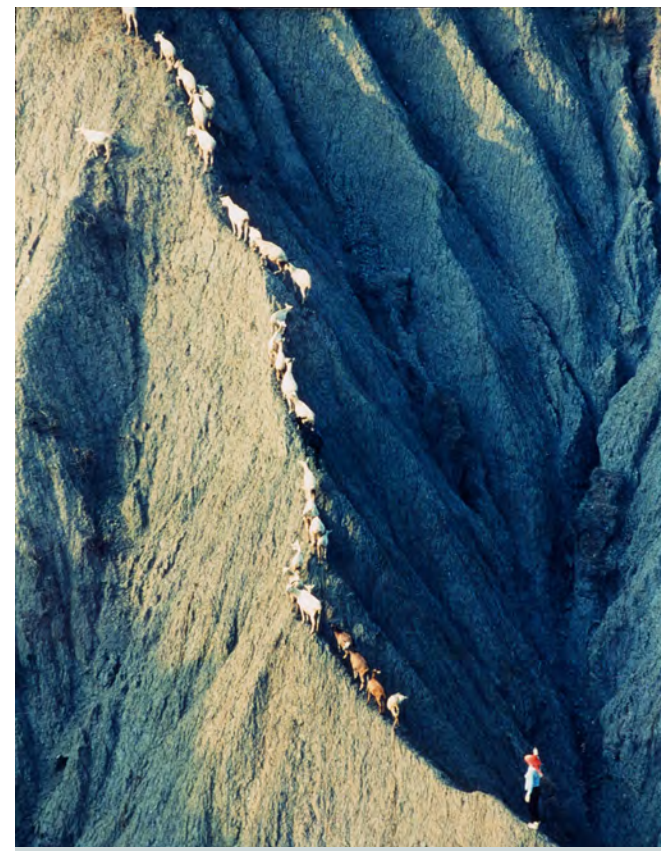
Currently, from 10%-20% of the world's farmland is degraded, and the rate of degradation has accelerated since 1950.[206] Most degradation is from excessive tilling, removal of vegetation, and overgrazing. Tropical soils are more susceptible to erosion, as they are older (not glaciated), subject to more rain, often on mountainous terrain, and require more careful management to prevent erosion by wind and water.

The world loses an estimated 26 billion tons of topsoil each year. The U.N. IPCC recently estimated that globally, the rate of soil loss is from 10 to 100 times greater than the rate of soil formation.[207] The report finds that the area of drylands in drought increases about 1% per year, and today about 500 million people live in lands experiencing desertification. Climate change is increasing the rate of desertification.

Desertification now claims over 14 million acres of arable land per year (40,000 acres per day) due to water withdrawals, overuse and mismanagement, removal of vegetation/trees (overgrazing, firewood cutting, over-tilling), leading to extensive soil erosion from wind and rain.[208] Hundreds of villages in Iran, Afghanistan, and China have been abandoned in recent decades after being buried by dust and sand storms. Both the Gobi and Sahara deserts continue to expand, and sand and dust storms in northern China, Mongolia, and West Africa occur 5 times more frequently than 50 years ago.[209]

Over 70% of the world's rangeland, which covers 20% of the Earth's land surface, suffers moderate-to-severe degradation from overgrazing, drought, and deforestation. Satellite imagery confirms that approximately 29% of the total world land area is significantly degraded, with some 3.2 billion people living within these degraded landscapes.[210] Salinization, where toxic salts concentrate in soil after evaporation of irrigation water, damages 20% of irrigated cropland worldwide, costing farmers billions of dollars each year.[211] Such salinization from irrigation is thought to have caused the collapse of the Sumerian Empire (now Iraq and Iran) in 2400 BC, that flourished for over 600 years.[212]

Fertilizer use has increased 10-fold since 1950, now at 130 million tons per year, contributing to more nitrogen flow than all natural processes combined. We are fertilizing the Earth in an uncontrolled experiment, causing harmful algal blooms, coastal dead zones, with profound ecological effects.[213]



Between 10% to 20% of the world's farmland is degraded, and the rate of degradation is accelerating. Most land degradation is due to excessive tilling, removal of vegetation, and overgrazing of livestock.

Tifernine Sand Dunes, east-central Algeria, Sahara Desert. Desertification now claims over 14 million acres of arable land per year (40,000 acres per day) due to unsustainable water withdrawals, mismanagement, and deforestation, leading to extensive soil erosion from wind and rain.

Freshwater

Water may well be the single most precious and sought after substance on Earth in the near future, even more than oil, creating conflict across the world. In much of the world, water is now more limiting to food security than availability of land.

Over 97% of the water on Earth is saltwater; 2% is freshwater ice in glaciers, ice caps, and permafrost. This leaves just 1% of Earth's freshwater readily available for biological use. Water use by humanity has increased three-fold over the last century, and humanity now uses about half of all the available freshwater on Earth. An estimated 70% of global water withdrawals are for agriculture (up to 90% in poorer countries), 20% for industrial use, and 10% for residential use, and all three withdrawals have increased dramatically.

Water Stress - Today, over 2 billion people don't have access to safe drinking water. By 2035, two-thirds of the world population will be living in water-stressed communities.[214] Already water supplies in many nations in Africa, Asia, and the Middle East are not sufficient to meet grain production needs, so they have to import grain, but there is obviously a limit to this.[215]

The U.N. reports that in 2017, 785 million people globally lived without basic drinking water services.[216] The WHO estimates that lack of access to clean drinking water and sanitation causes over 1 billion cases per year of diarrhea in children under 5, and 3 million deaths per year from dysentery and cholera.[217] An estimated 1.8 million people die prematurely each year due to water pollution.[218] And the daily task of procuring freshwater is not evenly shared by all.

Water may well be the single most precious and sought after substance on Earth in the near future, even more than oil, creating conflict across the world. In much of the world, water is already more limiting to food security than land.

Women and girls still carry most of the physical burden of transporting water in developing countries, reducing the time available for them to participate in productive activities and education.

U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[219]

It is estimated that 80% of global wastewater is discharged untreated into the aquatic environment.[220] This wastewater discharge includes from 300 million to 400 million tons of heavy metals, solvents, toxic sludge, and other hazardous industrial pollutants.

In most regions, water quality has worsened significantly since 1990, owing to organic and chemical pollution, such as pathogens, nutrients, pesticides, sediments, heavy metals, plastic and microplastic waste, persistent organic pollutants, and salinity.

U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[221]

A recent study reports that 65% of the rivers in 72 countries (mainly Asia and Africa) are contaminated with dangerous levels of human antibiotics.[222] This is a contributor to growing antimicrobial resistance in human populations, which is already responsible for over 700,000 deaths each year and is projected to cause 10 million deaths per year by 2030.

Water stress inhibits human development in many ways, and is particularly severe in Africa and South Asia:

India is suffering from the worst water crisis in its history and millions of lives and livelihoods are under threat. Currently, 600 million Indians face high to extreme water stress and about 2,000 people die every year due to inadequate access to safe water. The crisis is only going to get worse. By 2030, the country's water demand is projected to be twice the available supply, implying severe water scarcity for hundreds of millions of people and an eventual ~6% loss in the country's GDP.

NATIONAL INSTITUTE FOR TRANSFORMING INDIA (NITI), 2018[223]

The NITI report predicts that 21 cities in India, including Delhi, Chennai, and Hyderabad, will run out of groundwater by 2020, and that 40% of India's population will have no access to drinking water by 2030. Chennai, a city of 8 million in southern India, ran out of piped water

Seventy percent of global water withdrawals are for agriculture, 20% for industrial use, and 10% for residential use; all three have increased dramatically and are unsustainable.

Cholera epidemic, Goma, Congo. An estimated 1.8 million people die prematurely each year due to water pollution.

altogether in the summer of 2019, and relies on tanker trucks carrying water into the city. Violence has erupted over water. The same risk exists for most of South Asia, which had been reliant on rapidly dwindling glaciers and snowmelt from the Himalayas.

In addition, water stress causes food stress. It takes about 1,000 tons of water to grow 1 ton of wheat. Over-pumping of aquifers and river diversion for irrigation, essentially mining of groundwater, has led to what Lester Brown calls a "food bubble economy."[224] This may become particularly acute in China and India.

Many mega-cities are water stressed, including Beijing, Cairo, and Mexico City. Water is often taken from farmers and given to industry and cities, and there is little emphasis as yet on water conservation. In China there are several hundred cities suffering from acute water shortages. In 2014, China opened its massive South-North Water Diversion, a 2,400 km network of canals and tunnels bringing water from the wet south to the heavy industrialized and populated north.[225] This massive engineering project displaced over 345,000 villagers. More than half of China's 50,000 rivers have disappeared in the past two decades, and 70% of the rest of its freshwater is polluted.[226] Freshwater ecosystems in China are among the most severely degraded in the world.[227]

Cross-border conflicts over water are increasing. Many predict that the next major war in the Middle East may be over water. Turkey has dammed the Tigris and Euphrates rivers, causing the fertile crescent of Iraq and Syria to dry up. Israel, Lebanon, and the Palestinian Authority have a persistent conflict over river diversion. Mauritania and Senegal went to war over water from 1989-1991, and tensions are mounting between Sudan, Egypt, and Ethiopia over the Grand Ethiopian Renaissance Dam (GERD) project. Drought in southern Syria has contributed to the ongoing civil war there, and the genocide in Darfur, Sudan beginning in 2003 was caused in part by desire to control water and rangeland.[228]

Dropping Water Levels - Several of the world's large rivers now drop significantly in summer due to irrigation withdrawals and drought: the Indus, Ganges, Nile, Yellow, Amu Darya, and the Jordan. Several rivers no longer reach the sea. For instance, the 1,450-mile long Colorado River in the western U.S. last reached the Sea of Cortez in 1998 (except for an experimental managed "pulse flow" in 2014). The Colorado is drawn upon by over 30 million Americans, including the cities of Los Angeles, Phoenix, and Denver; is subject to extensive irrigation withdrawals; and now has over 100 dams and thousands of miles of diversions, making it one of the most heavily diverted rivers in the world.[229] Other major rivers that struggle to reach the sea include the Yellow River in China, the Amu Darya and Syr Darya in central Asia (flowing into the inland Aral Sea), and the Tigris and Euphrates in the Middle East. As a result, river and coastal wetland ecosystems have suffered severe degradation.

Hundreds of lakes around the world are drying up: Lake Chad (Africa), Mono Lake (California), and hundreds of lakes across China.[230] The Aral Sea, once one of the world's largest freshwater bodies, lost 80% of its volume over the past 50 years due mostly to water withdrawal for cotton irrigation, and is now mostly a dry, desolate salt flat.

An estimated 75% of the world's wetlands have been lost in the past century due to urbanization, rapid

Over 2 billion people don't have access to safe drinking water, and by 2035, two-thirds of the world population will be living in water-stressed communities.

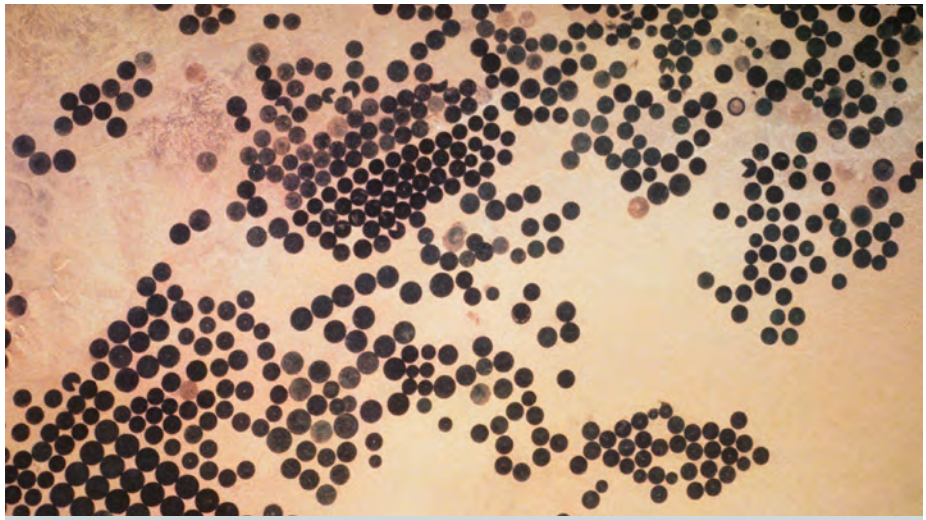
population growth, and agriculture.[231] And just since 1970, an estimated 40% of global wetlands have been lost, and the total economic cost of this extraordinary wetland loss is estimated at $2.7 trillion per year.[232] The ecological damage is incalculable.

Mining Groundwater - There are two types of underground aquifers: rechargeable (e.g., India, North China), and non-rechargeable "fossil" aquifers (e.g., Ogallala, deep North China, Saudi Arabia). The deep North China fossil aquifer, where they are drilling now to over 1,000 meters, is dropping by 3 meters per year, and near some cities it is dropping 6 meters per year.[233] A World Bank report predicts "catastrophic consequences for future generations" due to water shortages.

Much of the world today is simply "mining" groundwater from finite fossil aquifers. The water table is declining in nations where half of all humanity lives. In some populous arid countries, such as Mexico, Iran, Pakistan, and Yemen, water tables are dropping by 2-3 meters each year, putting hundreds of millions in real water crisis.[234] Saudi Arabia is "as water poor as it is oil rich," and irrigated agriculture will likely come to an end in the near future.[235] India is currently "suffering from the worst water crisis in its history," due to drought, population increase, and agricultural withdrawals from aquifers.[236] Millions of the world's refugees are water refugees. And the Indonesian capital Jakarta, a coastal city with 10 million residents, is sinking by up to 25 cm per year (2.5 m in the last 10 years) due mainly to subsidence from unsustainable groundwater withdrawals.[237] As a result, the Indonesian government is now proposing to move its capital from Jakarta to Borneo. Other major coastal cities, such as Houston and Beijing, are also sinking due to groundwater withdrawal. And groundwater removal has significant ecological effects. For instance, the Beaverpond Marstonia, a freshwater snail in the southeastern U.S., was declared extinct in 2017, due largely to groundwater removal for agriculture and urbanization.

Dams – Most large rivers of the world are now dammed or diverted for human uses, including flood control, irrigation, residential and industrial water diversion, and hydropower. Over 75% of the largest rivers in the U.S., Canada, Europe, and former Soviet Union

Most large rivers of the world are now dammed or diverted for human use; the number of large dams increased from 5,000 in 1950 to 50,000 today. These dams displace millions of people and cause enormous ecological impacts.



Irrigating the desert. Some aquifers are dropping by 6 meters per year due to unsustainable water use, and the World Bank predicts "catastrophic consequences for future generations" due to water shortages.

(the northern third of the world) are diverted by dams, reservoirs, and irrigation projects. Worldwide, the number of large dams (over 15 meters tall) grew ten-fold, from 5,000 in 1950 to 50,000 today, with half in China.[238] These dams have actually slowed the rotation of the Earth (by redistributing mass outward from the central rotational axis), destroyed river ecosystems, and shrunk ecologically important river deltas and floodplain habitats. Thousands of species of invertebrates, algae, protozoa, and bacteria inhabit these freshwater delta sediments and filter waste, decompose organics, maintain water quality, and are very sensitive to water levels, flow, and sediment loads.

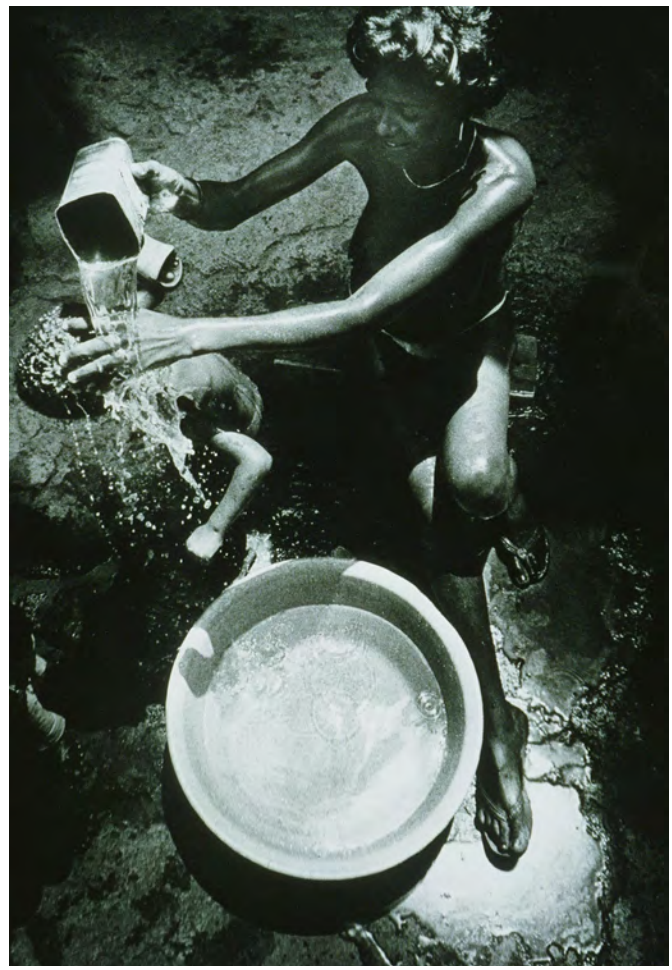
Dams have severely degraded these ecological services, and have had a particularly severe ecological impact in the Amazon Basin, where over 90% of the fish species are endemic. Dams in the northwestern U.S. have severely reduced migratory salmon populations, in turn reducing marine mammal populations (e.g., orca whales, sea lions, seals) that rely on the salmon as prey.

Dams restrict sediment loads flowing down rivers, leading to deltaic subsidence and other ecological effects. It has been estimated that some 50 cubic km of sediment is trapped behind dams each year, with a global total of 1,100 cubic km trapped by dams, amounting to one-fifth of the world's reservoir storage capacity.[239]

While counterintuitive, dams are not carbon neutral, and may actually add to climate change through increasing reservoir methane emissions due to rotting flooded vegetation.[240]

Dams have also directly displaced millions of people, forcing them from homes, and onto ever more crowded lands. In virtually all such cases, the lives of these environmental refugees displaced by large dam projects are significantly degraded from what they were prior to displacement, or what had been promised.

Although the rate of large dam construction has declined from its peak in the 1970s, International Rivers reports that hundreds of major dam projects are currently under construction, funded mostly by the World Bank and national export-import banks.[241]



Energy

The geological fact that trillions of tons of carbon have been stored as hydrocarbons (oil, gas, coal, methane hydrate) beneath the Earth surface - "fossil" fuel - has been enormously consequential to the biosphere. When humans sorted out how to extract this stored carbon and use it to fuel our industrial indulgence, the Anthropocene transformation of Earth began. Ecologically, humans have become unwitting "carbon worms" redistributing this stored carbon back up into the biosphere.

If human society had evolved without access to this enormous fossil energy resource, it would almost certainly have evolved along a much more gradual and sustainable trajectory. It is easy to imagine that without fossil fuel, Earth today would have a much smaller human population, living locally and sustainably, no internal combustion engines, no large factories, no climate change, and no mass extinction event.

But today, fossil fuel use (oil, gas, coal) continues to rise, and is now five-fold higher than 1950 levels, and contributes approximately half of our total ecological footprint.

The True Cost of Oil - Oil is perhaps the quintessential symbol of the Anthropocene. It has been such an important driver of the global environmental crisis that it may be useful to examine its impact in more detail.[242]

Some environmental costs of oil are obvious. Oil spills, such as the 1989 *Exxon Valdez* oil spill in Alaska and the 2010 *Deepwater Horizon* oil spill in the Gulf of Mexico, are easily recognizable oil disasters that attract widespread public condemnation. And many oil-producing areas of the world, such as the Niger Delta, the Caspian Sea, Persian Gulf, Siberia, and the Amazon have suffered decades of chronic oil spills.

But the true cost of oil goes far beyond the obvious damage from spills. More gradual, less visible costs of oil include chronic ecological habitat degradation from exploration, production, and pipelines; health costs from breathing polluted air; urban sprawl, traffic congestion and accidents in all major cities; and endless wars fought to secure oil supplies, costing thousands of lives and trillions of dollars and contributing to global terrorism.

Climate change from carbon emissions is incurring enormous present and future costs – storm damage, drought, wildfires, lost agricultural productivity,

A former Venezuelan oil minister called oil: "The devil's excrement."

infrastructure damage, climate refugees, disease, forest decline, marine ecosystem collapse, species extinctions, and lost ecosystem services - already exceeding $1 trillion a year.

Wherever it is produced, there is a "socio-political toxicity" of oil - a significant distortion of economic, social, and political systems. Rather than the prosperity promised, oil discoveries around the world often become more curse than blessing, causing social dysfunction, assimilation of Indigenous cultures, inflation, a decline in traditional exports, corruption, crime, and unsustainable growth. Former Venezuelan oil minister Juan Pablo Perez Alfonso, a founder of OPEC and once a true believer in the promise of oil, thought differently after he saw the corruption, greed, waste, and debt it caused, and came to call oil "the devil's excrement."[243]

The addictive power of oil was recognized as early as 1939, when Saudi Arabian King Abdul Aziz joked:

> *Do you know what they will find when they reach Mars? They will find Americans out there in the desert hunting for oil.*
>
> KING ABDUL AZIZ, SAUDI ARABIA, 1939[244]

Today, world oil use continues to rise, last year hitting a record 100 million barrels a day, and is still climbing. Humans have extracted and burned about 1 trillion barrels of oil, and there may be another trillion barrels of recoverable "conventional" oil left, along with several trillion barrels in unconventional reserves such as tar sands and oil shale formations. Extracting these tar sand and oil shale deposits is enormously energy-intensive and environmentally destructive. Saudi Arabia has oil reserves of 268 billion barrels, and promises to continue producing until "the last barrel" is produced.[245] And Venezuela has the largest oil reserves in the world, at an estimated 302 billion barrels.[246] Together, Venezuela and Saudi Arabia have 570 billion barrels of oil reserves, which if produced and burned, would clearly be "game over" for efforts to stabilize climate.

If we want a sustainable future, we'll have to leave most of this oil buried right where it is, as global climate cannot handle this much additional carbon. Yet the carbon-pushers see trillions of dollars in profits just waiting to be dug up, and are anxious to get to it, regardless of the consequences. As with any addiction, when the easy stuff is gone and supplies tighten, addicts become desperate and willing to take more risk to secure the next fix, such as hydraulic "fracking" or drilling in the Arctic and deep ocean basin.

President George W. Bush surprised the world in his 2006 State of the Union speech, admitting that: "We have a serious problem - America is addicted to oil," yet his administration did little to wean us from our oil addiction. And despite U.S. presidential candidate Barak Obama's promise to end "the tyranny of oil," and that if elected, "the rise of the oceans will begin to slow," President Obama later boasted that: "We're opening up more than 75 percent of our potential oil resources offshore. We've quadrupled the number of operating rigs to a record high. We've added enough new oil and gas pipeline to encircle

the Earth, and then some."[247] Today, the seas continue to rise, and the tyranny of oil continues.

Governments encourage fossil fuel addiction with annual subsidies of more than $5 trillion (6.5% of global GDP), including $1.4 trillion in China, $649 billion in the U.S., $551 billion in Russia, and $289 billion in the E.U.[248] These subsidies artificially depress prices and encourage unsustainable consumption; reduce government spending on health care, education, and social services; and keep alternative energy "uncompetitive." One 1998 study estimates that for every gallon of gasoline at the pump, we are actually paying as much as $14 a gallon in additional "hidden" costs. Yet, we continue to ignore these hidden costs, paying some indirectly through income taxes, while deferring most to future generations. We are tricking ourselves into using "cheap and easy" oil as fast as we can pump it out of the ground.

In all oil-producing regions of the world, governments are "captured" and politically controlled by oil interests by ensuring policies to limit regulation, lower taxation, and favor production and demand for oil over development of low-carbon alternatives. The 2010 Supreme Court Citizens United ruling allows companies to pour unlimited funds into oil-friendly candidates and causes without public disclosure. Media is awash in adds keeping us hooked on the stuff. And millions have been spent on a strategic disinformation campaign to deceive the public about the real costs of oil. Clearly, the drug pushers are running the show.

Perhaps the most pernicious cost of oil is that it has fueled a dangerous, unsustainable expansion of the ecological footprint of human civilization. With access to artificially "cheap and easy" oil over the past century, human population has quadrupled and resource consumption has increased many times more, now significantly exceeding Earth's carrying capacity. Without access to fossil carbon, humanity almost certainly would have evolved on a more sustainable trajectory. But by not accounting for its true cost, oil has allowed us to dig ourselves deeper into an unsustainable hole. The environmental debt we are accruing is far larger and more consequential than the total financial debt of nations.

Oil is perhaps the quintessential symbol of the Anthropocene. Oil use continues to rise, now surpassing 100 million barrels per day.

If we want a sustainable future, we'll have to leave most of the remaining coal, oil, and gas in the ground.

As oil is a finite resource, the world will indeed reach "peak oil" at some point, despite claims by petro-optimists. We are now at, or near, the beginning of the end of the age of oil. And as Lester Brown has said, peak oil may well be a "seismic economic event," and world history may well be recorded as BPO (Before Peak Oil) and APO (After Peak Oil).[249] It is clear that oil is a problem for human development, not the solution. The sooner we wean ourselves from oil, the better off we'll be.

Nuclear Power – There are currently 450 nuclear fission power plants in 30 countries worldwide, none with a clue as to how to safely manage the long-lived radioactive waste they generate, achieve adequate protection from terrorism and weapons proliferation, or operate entirely safely. Today, at least 60 new nuclear plants are under construction, and hundreds more are proposed. China has the largest expansion effort, with 20 plants now in construction.

While these fission reactors are indeed a no-carbon energy alternative, they also present significant risk, including long-lived radioactive waste, operational safety, and the potential for nuclear weapons proliferation. On this last point, six of the nine nuclear weapons states today built their weapons from civilian nuclear power technologies, either by enriching uranium beyond the low concentration (5%) needed for power plants to highly enriched uranium (90%), or by recovering spent fuel for plutonium (as in North Korea). And regarding waste, one of the radioactive waste products of nuclear plants, Plutonium-239, has a half-life of 24,000 years.[250]

Regarding safety, two historic disasters are well known – Chernobyl and Fukushima. The April 26, 1986 Chernobyl disaster released at least 50 tons of radioactive material into the air, 200-times the amount of radiation released in the Hiroshima and Nagasaki detonations. Radiation spread over Europe, and many were killed and sickened. Experts predict as many as 250,000 future cancer cases may derive from the Chernobyl disaster, that the Exclusion Zone (now a National Park) will stay radioactive for 40,000 years, and that it won't be habitable for 600 years. While Soviet government estimates put the human death toll at 31, independent scientific estimates put the death toll in the thousands.[251]

Twenty-five years later, on March 11, 2011, a large earthquake-generated tsunami off Japan disabled the emergency generators for the Fukushima Daiichi nuclear power plant on Hokkaido Island, and as water pumps could not cool the reactor cores, this led to 3 reactor core meltdowns, a hydrogen air explosion, and the substantial release of radioactive material over the following three-day period. The radiation release is expected to lead to hundreds of cancer deaths per year over future decades. Traces of radioactive material from Fukushima have now been found in the northern Bering Sea off Alaska.[252]

If government subsidies for radioactive waste disposal, insurance, security, and decommissioning are eliminated, nuclear fission is actually a cost-prohibitive energy option. Yet some energy experts still call for a "nuclear renaissance" to combat global warming, proposing to expand nuclear fission plants from the 450 currently to 5,000 this century. This seems like a fools-bargain – it would almost certainly create more problems than it solves. And as discussed in Section IV, there is no need for nuclear fission power to solve our energy and climate crisis.

Atmosphere

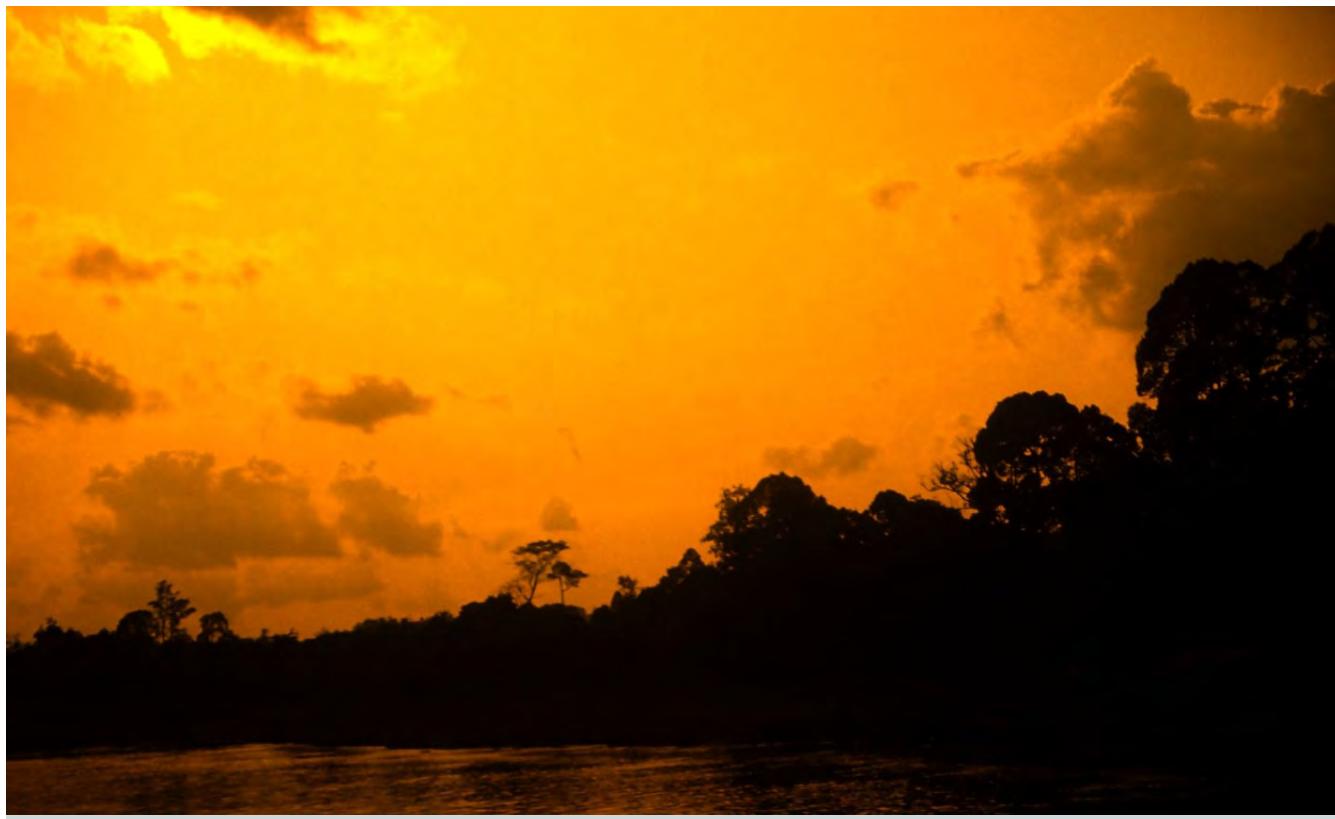
Air Pollution from soot, smoke, sulfur dioxide, nitric oxide, carbon monoxide, ozone, dust, and lead exceeds health limits in many cities around world on a daily basis. The U.N. World Health Organization reports that 19,000 people per day - 7 million per year - die prematurely from air pollution, largely from cancer, heart and lung disease, and stroke due to breathing fossil fuel emissions. Ninety percent of the world's population now breathes polluted air.[253] Air pollution costs human welfare approximately $5 trillion per year.[254] Children in some cities inhale the equivalent of two packs of cigarettes per day just by breathing the air.[255] Asthma rates continue to rise, now afflicting over 100 million people. In some countries, motor vehicle pollution kills more people than vehicle accidents. For instance, in the U.S., an estimated 70,000 people are killed each year by air pollution, compared with 40,000 a year from traffic accidents. When Bangkok officials closed schools recently due to toxic levels of particulate air pollution, they deployed dozens of drones to spray a mixture of water and molasses into the air attempting to remove airborne particulates.[256] In October 2019, air pollution was so bad in Delhi (5-times higher than "very dangerous" levels) that it triggered home smoke alarms, closed schools, and diverted flights. A recent study in China found that air pollution lowers human cognitive abilities.[257]

Noise and Light Pollution are increasingly recognized as cumulative environmental stressors affecting ecosystems and human health. Globally, noise pollution from transportation (cars, highways, trains, and airports), and industrial sources continues to increase to hazardous levels, leading to significant health impacts including hypertension, anxiety, aggression, lost attentiveness, heart disease, and billions of dollars lost to the economy. Anthropogenic noise affects species' abilities to communicate (by masking intraspecific communication), find mates, feed, navigate, and occupy preferred habitats.

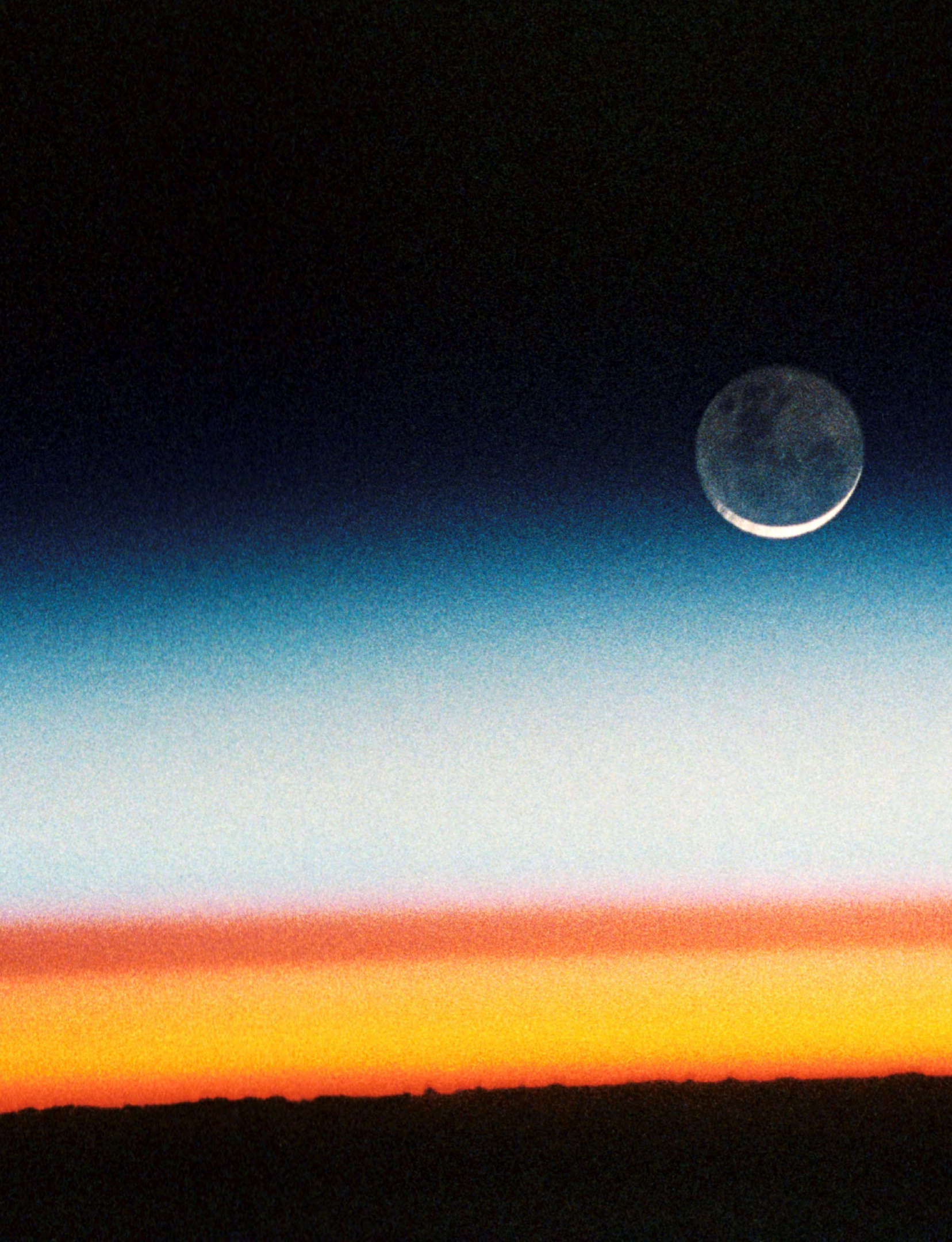
Nineteen thousand people per day, 7 million per year, die prematurely from air pollution.

Similarly, light pollution has increased steadily due to increased energy use, population growth, and economic expansion. One recent study using satellite imagery found that globally, light pollution has increased by about 2% each year, and presents significant risk to some 30% of all nocturnal vertebrate species and 60% of nocturnal invertebrates, as well as plants and microorganisms.[258] The impact of artificial lighting is particularly severe in nocturnally migrating birds that have evolved to orient in dark night, but are now having difficulty due to increased ambient lighting. As the study observed: "the world has experienced a 'loss of the night'." Another 2016 study reports that: "More than 80% of the world and more than 99% of the U.S. and European populations live under light-polluted skies. Views of our Milky Way galaxy are hidden from more than one-third of humanity, including 60% of Europeans and nearly 80% of North Americans."[259] In response, some areas have become International Dark Sky Reserves and Radio Quiet Zones, to protect dark skies and quiet as precious natural assets.

The Stratospheric Ozone Hole caused largely by chlorofluorocarbons (CFCs) used in coolants, aerosol propellants, insulation, and solvents led to increased ultraviolet-b ("UVb") exposure, and thus increased skin cancer, damage to eyes and immune systems, and caused significant effects to ecosystems and crops. One of the true international environmental success stories has been the 1987 Montreal Treaty which banned CFC production and use. Without the Montreal Treaty, we would have had five-times the ozone depleting chemicals and twice the surface UVb radiation exposure by 2050. Since the treaty went into force, emissions of ozone-depleting chemicals have steadily declined. The ozone hole is beginning to stabilize and might close completely by 2050. This success is an important reminder of how we can cooperate to remedy other environmental problems.



Climate change from the combustion of fossil fuels, livestock agriculture, and deforestation are core drivers of the Anthropocene ecological crisis.



Climate Change

Human-caused climate change from the combustion of fossil fuels, livestock agriculture, cement production, and deforestation is a core driver of the Anthropocene ecological crisis. As former U.S. Vice President Al Gore stated decades ago, climate change is "an inconvenient truth" for many in government and the fossil fuel industry.[260]

Due primarily to the burning of fossil fuels, atmospheric CO^2 levels have increased from 280 parts per million (ppm) in pre-industrial times (approximately 200 years ago) to over 415 ppm today – an increase of more than 30%. This is the highest the global CO^2 level has been for over 3 million years.[261] Atmospheric CO^2 concentration continues to increase on average from 2.5 ppm – 3 ppm each year.[262] At this rate, CO^2 levels could reach 450 ppm by 2030, and 500 ppm by 2050, with catastrophic consequences.

Even the most optimistic CO^2 reduction scenario in 2017, "Project Drawdown," predicts that even if the world achieves 100% clean renewable energy by 2050, atmospheric CO^2 concentration would continue to rise until 2045, and only then begin declining.[263] So even in this "optimum scenario," CO^2 concentrations would rise well above 450 ppm, and global temperatures would exceed the critical +2°C (+3.6°F) threshold. Clearly, we need more aggressive reductions than this (see discussion in Section IV).

In addition, levels of other greenhouse gases, notably methane, are steadily increasing. Methane (CH^4) from decaying organic material in wetlands and peat bogs, livestock, landfills, permafrost melt, biomass burning, and natural gas infrastructure, is a much more potent greenhouse gas than CO^2 (as much as 80 times more potent for the first 20 years in the atmosphere). Fortunately, methane persists in the atmosphere for a much shorter time, for decades rather than centuries. The global atmospheric methane level has increased from 0.78 ppm in pre-industrial times to 1.865 ppm today, an increase of about 2.5 times, and is now the highest level in over 800,000 years.[264]

The heat-trapping "greenhouse" physics of CO^2 and other greenhouse gases is well established. Even accounting for other drivers of global climate, including Earth's wobble on its axis, eccentricities in orbit around the sun, variations in solar output, and volcanic eruptions, it is now well-established that fossil fuel burning by humans is a main driver of current climate change.

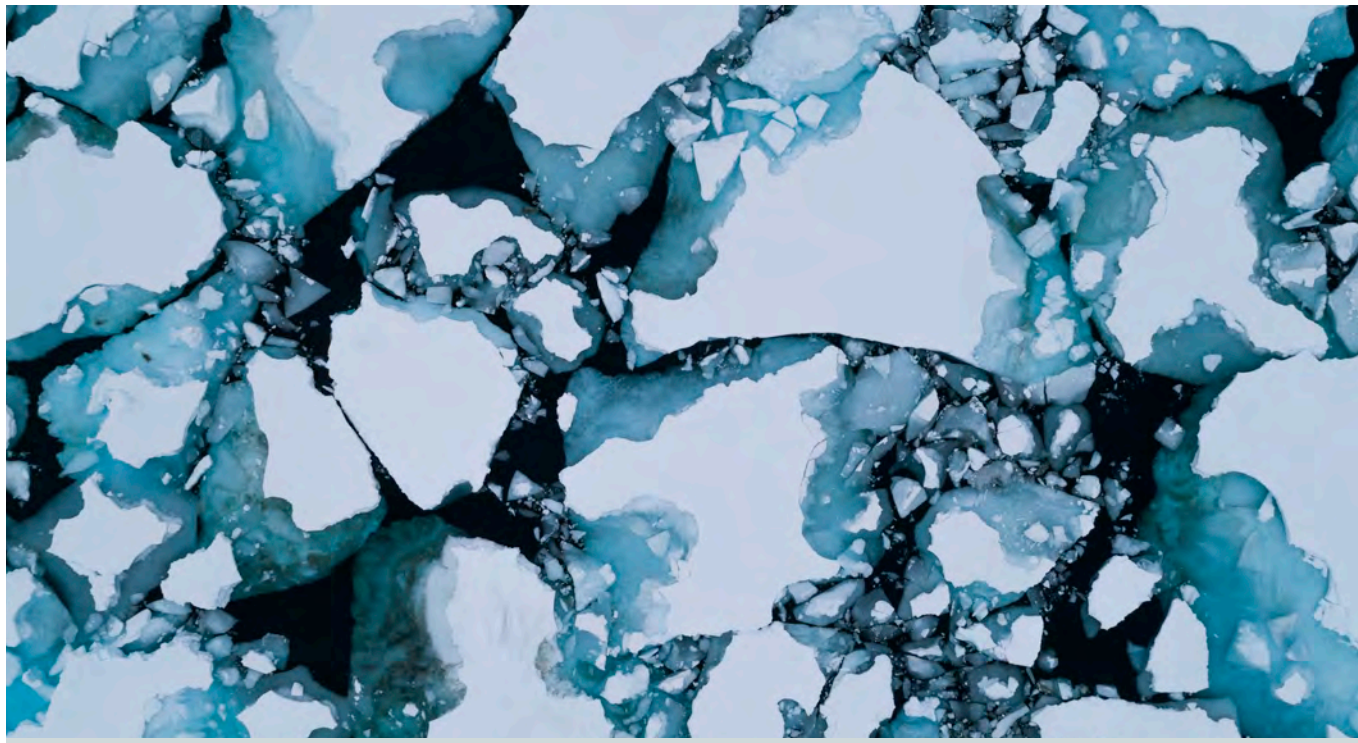
The U.N. Intergovernmental Panel on Climate Change (IPCC) concludes that "most" of the warming over the past 50 years is human induced, and there is no longer a credible scientific debate about this point.[265] These are quantitatively measured observations: fossil fuel combustion, agriculture, and deforestation increase carbon emissions; these emissions increase atmospheric greenhouse gas concentrations; rising levels of greenhouse gases trap infrared back-radiation from the Earth surface (the "greenhouse") causing global temperature to rise; increasing temperature leads to melt of the cryosphere (sea ice, glaciers, and permafrost), sea level rise, and warming oceans; and CO^2 absorption increases ocean acidity. These observations are measurable, unequivocal, irrefutable, and not open to debate.

Given that more than 2.5 trillion tons of CO^2 (equivalent) have been released since the industrial revolution, and that much of this remains in the atmosphere today, scientists conclude there is already a significant "committed warming" that is now unavoidable. It seems certain that global temperature increase will exceed the lower critical threshold of +1.5°C (+2.7°F) this century and perhaps even exceed the +2°C (+3.6°F) threshold.

Since 1950, annual global CO^2 equivalent emissions (standardized to include all sources of greenhouse gases) have increased from about 5 billion tons to 38 billion tons (10 billion tons of carbon) today, a seven-fold increase.[266] Of these annual emissions, it is estimated that about 44% remains in the atmosphere (CO^2 for 50-200 years), 31% is absorbed by terrestrial plants, and 26% (or more) is absorbed in the oceans where it forms carbonic acid, and leads to ocean acidification. The rate of increase in carbon emissions is unprecedented in recent geologic history, now estimated to be ten times faster than at any time in the past 300 million years.[267] Again, if the present emissions trajectory continues, atmospheric CO^2 concentrations exceeding 500 ppm will be inevitable as early as 2050, with catastrophic effects.

Hurricane Elana, Gulf of Mexico, 1985.

The 100 largest fossil fuel companies in the world today have contributed over half of the cumulative global industrial greenhouse gas (GHG) emissions (almost 1 trillion tons of CO^2 equivalent) since the beginning of the industrial revolution (1750).[268] And just since 1988 (the year the IPCC was founded), more than half of the global industrial GHG emissions came from just 25 corporate and



Today, the climate is warmer than at any time in human history.

Crack in Larsen A Ice Shelf, Antarctica. Since 1950, annual global CO^2 emissions have increased from about 5 billion tons to 40 billion tons today. The U.N. Intergovernmental Panel on Climate Change (IPCC) concludes that most of the warming over the past 50 years is human induced.

state producers.[269] The largest industrial emitters include China (coal), Aramco (Saudi Arabia), Gazprom (Russia), ExxonMobil, Shell, BP, and Chevron. As far back as 1982, Exxon scientists had (internally) predicted that fossil fuel burning would increase global atmospheric CO^2 levels to 415 ppm by 2019. Precisely as predicted, atmospheric CO^2 just reached this level.[270] Consequently, the State of New York sued Exxon for "allegedly defrauding investors for years by deliberately downplaying the climate risks to its business and financial health."[271]

Today, the climate is warmer than at any time in human history. As the U.N. concluded in 2019: "Eight of the ten warmest years on record have occurred within the past decade."[272] July 2019 was the hottest month ever recorded.[273] Over the past century, global average temperature has increased by 1°C, and unless emissions drop dramatically soon, global average temperature is projected to increase another 2°C to 4°C (for a total of 3°C-5°C over pre-industrial baseline) by the end of this century.

A 2018 U.N. IPCC report warns that there will be extreme impacts by 2040 if global average temperatures rise another 0.5°C, for a total of +1.5°C.[274] Previous estimates had put this threshold at 2°C (the target called for in the Paris climate accord). Yet, with current emissions trajectories, a 1.5°C rise is already committed, and a 2°C warming seems likely. If fossil fuels continue to be extracted and burned over the next 28 years at the same rate they were between 1988 and today, world temperatures will rise by 4°C by the end of this century.[275]

Impacts: The climate crisis is now causing a rapid loss of Arctic sea ice, melting of the Antarctic and Greenland ice sheets, melting permafrost and glaciers, rising sea level, ocean acidification, serious ecological effects in all ecosystems (including loss of biodiversity), more frequent and intense storms, floods, drought, heat waves, crop failures, wildfires, increased human migration, and trillions of dollars in annual economic losses. These impacts will increase dramatically in coming decades.

Extreme heat waves already kill thousands of people each year, and this will only get worse. A 2019 scenario analysis estimates that with a +3°C temperature rise by 2050, 55% of the world population, on over 35% of the land area, would experience over 20 days of *lethal* heat each year, "beyond the threshold of human survivability."[276] In 2015, over 2,400 people died in India due to excessive heat, when temperatures hit 48°C (118°F) before the cooling monsoon rains. The U.N. World Health Organization (WHO) predicts that 250,000 people will die each year from climate change effects between 2030 and 2050, but other studies believe that is a "conservative estimate."[277] High temperature records were set across the northern hemisphere in the summer of 2019. Studies conclude that: "the projected rate of temperature change for this century is greater than at any extended global warming period over the past 65 million years."[278]

The number of severe weather disasters has increased four-fold since the 1960s. The U.N. warns of a global "climate apartheid" where the rich can better protect themselves from climate impacts than the poor.

The U.N. warns of a global "climate apartheid" by 2030, in which the rich can better protect themselves from climate impacts, but the poor are left behind to fend for themselves.[279] It is estimated that 120 million people will be forced into poverty by 2030 due to climate change.

Melting polar ice sheets and glaciers and thermal expansion of seawater have led to global sea level rise over

Global temperatures are on a trajectory to exceed the lower critical threshold of +1.5°C (+2.7°F), and perhaps even exceed the +2°C (+3.6°F) catastrophic threshold later this century.

the past century of about 20 cm/8 inches, and sea level is projected to rise by a total of 1 to 2 meters by 2100. The predicted "great thaw" is now well underway. And the *rate* of sea level rise has doubled in the past 20 years. Sea level rise has already inundated hundreds of low-lying islands and shorelines, requiring thousands of people to relocate. Many large, low-lying cities are at severe risk from sea level rise, including Miami, New York, Mumbai, and Shanghai. A 2-meter sea level rise would displace over 200 million people.

Arctic sea ice cover has declined by about 1% a year, and its average thickness has declined from 4 m/12 feet to 1.3 m/4 feet. Multi-year Arctic sea ice is almost gone entirely, and the Arctic Ocean is expected to be virtually ice-free in summer by 2040. Permafrost temperature has increased in some regions of Alaska from -8°C/17°F to -2°C/28°F, nearing the melting point, which once reached will release large amounts of carbon as methane (a potent greenhouse gas). Shoreline erosion due to reduced sea ice cover, combined with more intense storms, has claimed several hundred feet of shoreline a year at some locations in the Arctic. At least 31 Alaska coastal villages threatened by shoreline erosion, flooding, and rising seas will likely need to relocate further from the shore, costing roughly $100 million per village, totaling billions of dollars.[280]

The massive, 2-mile thick Antarctic ice sheet (twice the size of Australia) holds 70% of the world's surface freshwater. Huge icebergs, some of them several thousand mi^2 in surface area, have broken off of the Antarctic ice sheets just since 2000. The speed of disintegration of the Antarctic ice shelf is staggering. Antarctic Ice Sheet melt has increased six-fold in just the past 40 years, and if this melt rate continues, global sea levels could rise by 3 meters by the end of the century.[281]

And just since 2000, the melt of Greenland's 2-mile thick ice sheet has increased six-fold, now a major contributor to sea level rise. In July 2019 alone, record-breaking heat melted 197 billion tons of Greenland ice, three times more than normal.[282] The cold, fresh water from Greenland ice melt is disrupting deep ocean thermohaline circulation, the "deep ocean conveyor belt," and is altering heat distribution across the Atlantic. Due to increased ice melt from the Greenland Ice Sheet, the Atlantic Meridional Overturning Circulation (AMOC) – part of

the deep ocean heat transfer conveyor belt including the surface Gulf Stream – has weakened by 15% to 20% in the past 150 years.[283] The slowing of this huge Atlantic heat transfer mechanism is impacting weather systems across the northern hemisphere.

Warming seawater has killed vast areas of the world's coral reefs, and increased the frequency and intensity of storms. Storm damage has increased to over $100 billion a year (mostly in Asia), killing on average 25,000 people a year, and displacing over 30 million people as environmental refugees (more than the 12 million political refugees each year). The number of severe weather disasters has increased four-fold since the 1960s. Insurance companies are now in a panic, and they should be. Economic damage from storms increases by about 10% each year. The 2017 back-to-back hurricanes Harvey in Texas, Irma in the Caribbean, and Maria in Puerto Rico together cost an estimated $265 billion, almost twice the cost of hurricane Katrina in 2005.[284] And over 3,000 people were killed in these three 2017 hurricanes.

Mountain snow packs and glaciers, "reservoirs in the sky," are in decline globally as warming leads to more rain rather than snow, with floods in rainy season and drought in the dry season. These mountain water reservoirs are projected to decline by 70% in the western U.S. by 2050. All of the major rivers in Asia (Indus, Ganges, Yangtze, Mekong, Yellow), originate in the Himalayas, now called "The Third Pole."[285] With reduced snow and glacial ice in these mountains, water is already in critically short supply to this densely populated region. Lack of water will reduce wheat and rice harvests, and increase water-stress for hundreds of millions of people. This is a problem in all mountains globally, including the western U.S., the Andes, the Alps, and Africa.

Climate change affects agricultural production, forest pests, wildfires, and insect-born disease outbreaks, such as malaria-causing mosquitoes in Africa. The drought-affected surface area of Earth has doubled from 15% in 1970 to over 30% today.[286]

Ecological effects of climate change are already enormous, and they will get worse throughout this century - the only question is how much worse. Some terrestrial species are moving toward the poles, others to higher elevations. Devastating wildfires continue to expand, in 2019 burning millions of acres across the Arctic and tropics. Marine species are moving to cooler deeper waters and toward the poles. Climate change could drive more than a quarter of all land animals and plants to extinction this century. The recent IPBES Global Assessment found that the distribution of 47% of terrestrial flightless mammals and 23% of threatened birds might have already been impacted by climate change.[287]

Profound ecological effects in polar seas are expected, including reduced populations of sea-ice dependent species (polar bears, ice seals, walrus), seabirds, and fish. Recently, massive mortalities of seabirds and marine mammals have occurred in Alaska waters, all related to record warm waters.

Sea level has risen 8 inches over the past century and is expected to rise another 3 to 6 feet by 2100.

2015 U.N. Paris Climate Agreement - The 2015 U.N. Paris climate agreement entered into force on November 4, 2016, and while it is a significant step forward in international cooperation on climate change, the agreement itself unfortunately does not sufficiently reduce global carbon emissions to safe levels, ensuring climatic stability at +1.5°C global temperature increase over pre-industrial levels.[288]

The Paris Agreement fails to reduce total greenhouse gas emissions for decades; the voluntary commitments of governments (Nationally Determined Contributions) are collectively insufficient to meet the agreed target (+2°C); there is no enforcement mechanism to ensure compliance with the voluntary emissions reduction pledges; and there is no agreed fee (tax) for carbon emissions. To many involved in the climate issue, Paris was a tragic failure.

On this, the 2019 U.N. GEO 6 states:

> *Current nationally determined contributions, presented in Paris in 2015, constitute only one-third of the mitigation required to establish a least-cost pathway for staying well below 2 degrees Celsius.*
>
> U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[289]

Climatologist James Hansen, a leader in climate science, told *The Guardian* about the Paris Agreement:

> *It's a fraud really, a fake. It's just bullshit for them to say: 'We'll have a 2° Celsius warming target and then try to do a little better every five years.' It's just worthless words. There is no action, just promises. As long as fossil fuels appear to be the cheapest fuels out there, they will continue to be burned.*[290]
>
> JAMES HANSEN, CLIMATOLOGIST, 2015[291]

The Paris Agreement itself admits that it fails to hold warming to the maximum tolerable increase of +2°C over pre-industrial levels, noting:

> *...with serious concern the urgent need to address the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with holding the increase in the global average temperature to well below 2 degrees Celsius above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 degrees Celsius...* [and]...
>
> *...that the estimated aggregate greenhouse gas emission levels in 2025 and 2030 resulting from the intended nationally determined contributions do not fall within least-cost 2 degrees Celsius scenarios but rather lead to a projected level of 55 gigatonnes in 2030, and also notes that much greater emission reduction efforts will be required than those associated with the intended nationally determined contributions in order to hold the increase in the global average temperature to below 2 degrees Celsius above pre-industrial levels by reducing emissions to 40 gigatonnes or to 1.5 degrees Celsius above pre-industrial levels by reducing to a level to be identified...*[292]
> *(emphasis added)*

Put simply, this is a stark admission in the Paris Agreement itself, that even if it were to be implemented and complied with fully (which is unlikely, particularly given the recent U.S. withdrawal), global carbon emissions will

continue to increase beyond critical levels. While many countries (including the U.S.) commit to reduce total emissions, China (the top emitter) doesn't commit to cap its emissions until 2030, and India (the third highest emitter) commits only to reduce the carbon *intensity* of its economy, not reduce total emissions. In fact, carbon emissions from China and India could double by 2030. The Paris Agreement may simply rearrange the deck chairs on a sinking ship.

Melt pond, Greenland Icecap.

Despite the temporary slowing of global emissions growth during the 2009 recession, and the 2015/2016 economic slowdown with reduced coal use in China, global CO^2 emissions increased significantly in 2017 and 2018, and, without significant intervention, are predicted to increase from the current 38 billion tons per year to 55 billion tons by 2030, more than a 50% increase. Instead of reducing atmospheric CO^2 concentrations from the current 415 parts per million (ppm) to 350 ppm and limiting warming to +1.5°C, this emissions increase would set a course for 450 ppm or even 500 ppm, and a 3°C to 4°C increase over this century, which most climate scientists warn would be disastrous.

Even with the Paris accord, it is a virtual certainty that climate change will continue to get worse. But while it is already too late to prevent dangerous climate change, we can and must slow it as much and as quickly as possible (see Section IV).

Despite 40 years of global climate negotiations, with few exceptions, we have generally conducted business as usual and are largely failing to address this predicament. The climate crisis has arrived and is accelerating faster than many scientists expected. It is more severe than anticipated, threatening natural ecosystems and the fate of humanity. Especially worrisome are potential climate tipping points and nature's reinforcing feedbacks that could lead to a catastrophic "Hothouse Earth," well beyond the control of humans. These climate chain-reactions could cause significant disruptions to ecosystems, society, and economies, potentially making large areas of Earth uninhabitable.

WORLD SCIENTISTS' WARNING OF A CLIMATE EMERGENCY, 2019[293]

Due to increasing freshwater runoff from Greenland ice melt, the Atlantic deep ocean current has weakened by 20% in the past 150 years, affecting weather systems across the Northern Hemisphere.

The world ocean today is more polluted and overexploited than at any other time in history. Simply stated, we put too much pollution into the oceans and take too much biomass out.

Oceans

> *With every drop of water you drink, every breath you take, you're connected to the sea. No matter where you live on Earth.*
>
> SYLVIA EARLE, OCEANOGRAPHER, 2009[294]

Once thought to be inexhaustible, the oceans clearly have ecological boundaries that have been exceeded. All is not well beneath the waves. For too long, offshore ecosystems have been out of sight, out of mind. We are, after all, terrestrial primates and tend to pay more attention to terrestrial issues. Because of this, ocean health has suffered.[295]

Despite some localized improvement and greater attention to the problem, the ocean today is more polluted and overexploited than at any other time in history. Simply stated, the problem is that we put too much pollution into the ocean, and take too much biomass out. Both trends have accelerated recently, and act synergistically. Currently, approximately 17% of coastal seas (within 200-mile Exclusive Economic Zones), and 4% of high seas (international waters) are in protected status.[296] While the area protected has doubled in the last 10 years, most of this is in less threatened offshore pelagic ("blue water") ecosystems rather than the productive, heavily exploited continental shelf ecosystems most in need of protection.

Pollutants – Each year, thousands of tons of Persistent Organic Pollutants (POPs), heavy metals, radioactive substances, oil, nutrients, sediment, and untreated

sewage enter the sea. Of the pollutant load entering the oceans, an estimated 44% is from land-based sources (via river runoff), 33% atmospheric (also mostly from land), 12% from shipping, and 10% from deliberate dumping. Dangerous contaminants found in fish include PCBs, DDT, and mercury, and are being ingested by humans. Each year, over 30 billion tons of industrial and other pollutant wastewater flow down China's Yangtze River (90 million tons per day), into the East China Sea. Persistent Organic Pollutants have even been detected in the deepest parts of the oceans, in the Mariana Trench.[297]

Marine Debris – Each year over 8 million tons of plastics enter the oceans, 80% from land-based sources, from poor landfill practices in Asia and lost fishing gear, at a rate that has increased ten-fold since 1980.[298] Over 90% of this plastic debris enters the oceans from just 10 rivers (two in Africa, eight in Asia): the Nile, Niger, Ganges, Indus, Yellow, Pearl, Yangtze, Haihe, Mekong, and Amur.[299] Plastic debris is persistent, takes decades or centuries to degrade, and has serious impacts on marine wildlife mainly through ingestion and entanglement, and kills thousands of marine mammals, seabirds, sea turtles, and fish each year. One study estimates that if the current rate of marine plastic discharge continues, by 2050 the oceans will contain more plastic than fish (by weight).[300] One of the largest components of plastic debris in the oceans is cigarette filters. The ocean gyre between North America and Hawaii has concentrated over 3 million tons of plastic debris, and is now called the "Great Pacific Garbage Patch." And microplastics (less than 5 mm diameter), from road/tire abrasion, facial scrubs and other cosmetic products, packaging, soft contact lenses, and chemical industry micro-pellets are now an increasingly worrisome component of marine debris in all pelagic ecosystems. A recent study estimates the average human intake of these ubiquitous microplastics at between 74,000-121,000 plastic particles each year through food, drinking water (mainly bottled water), and air.[301]

Nutrients/Dead Zones – Over the past 50 years, overuse of nitrogen and phosphorous agricultural fertilizers largely for corn and soybean farming, flushing into and down rivers has formed over 600 hypoxic dead zones in coastal waters off river deltas around the world. Fifty such hypoxic dead zones are along U.S. coasts, the most notable being the Mississippi Delta in the southern U.S. This over-enrichment (eutrophication) also causes harmful algal blooms, oxygen depletion, and seasonal fish kills in coastal waters.[302]

Undersea Noise – Undersea noise may now be the most pervasive unregulated pollutant on Earth. Marine acousticians conclude that undersea noise has doubled every decade since 1950.[303] Much of this comes from merchant

shipping. The number of ships sailing the world ocean has increased three-fold in 50 years, and the total tonnage has increased seven-fold. This increases the loud, low frequency noise (mainly from propeller cavitation and engine noise) that travels thousands of miles and has deleterious effects on cetaceans. As well, seismic air guns used in offshore oil exploration add significant injurious noise to the ocean environment.

Climate Change (Heat and Acidification) - Oceans have absorbed about 500 billion tons of CO^2 emitted by human activities, and this dissolved CO^2 forms carbonic acid. Oceans have become about 26% more acidic in the past century (pH has declined from 8.2 to 8.1), and this affects all calcium carbonate shell-forming organisms, such as coral reefs and clams, and some important plankton species such as pteropods (small planktonic mollusks) are already experiencing difficulty forming shells in acidic ocean waters.[304] As well, oceans have absorbed more than 90% of the excess *heat* from the atmosphere.[305] This increased heat results in thermal expansion of ocean waters, accounting for about a third of the measured rise in sea level, increased storm frequency and severity, coral bleaching and death, and shifts in marine species' ranges. And increasing melt of polar ice sheets and sea ice is affecting deep ocean circulation in the world ocean (such as the Atlantic Meridional Overturning Current), which will affect weather systems across the planet.

Coral Reefs – Coral reefs (globally covering an area of approximately 250,000 km^2) are dying from increasing water temperature, pollution from coastal areas, and overexploitation. An estimated 50% of world coral cover has been lost since 1870.[306] Coral "bleaching" (where warm water causes corals to expel their photosynthetic symbionts) began significantly in 1980, when coral bleaching passed a "tipping point" from which reefs are not expected to recover. Several severe mass bleaching events have occurred since 1980 (in 1998 and 2010), and the interval between these bleaching events has now shrunk to only about 6 years, while reef recovery rates are generally about 10 years.[307] The most severe global coral reef bleaching event began in 2015 after the hottest summers ever recorded and continues today. This event has been "the longest and most damaging recorded," affecting over 70% of world coral reefs.[308] More than 50% of Australia's Great Barrier Reef has been impacted by the recent bleaching event, and scientists now fear that continued warming will cause a complete collapse of the Great Barrier Reef by 2100.

Coral reefs are also affected by acidification, coastal pollution, sewage discharge, sedimentation, coastal development, overfishing, cyanide fishing used to collect reef fish for the aquarium trade, and dynamite fishing for human consumption. These two destructive fishing techniques - cyanide and dynamite - alone may destroy most of the world's coral reefs in the near future, even without warming and acidification. Today, at least 20% of all reefs are so degraded they are unlikely to recover, and another 50% are considered "on the edge." Regarding the current crisis in coral reef ecosystems, the U.N. recently stated that: "Governments should prepare for a dramatic decline (if not a collapse) of coral reef-based industries and ecosystem services."[309]

Coastal Development – Over half the world's population now lives in coastal areas, and this huge population pressure impacts the flow of water, nutrients, pollutants, and the loss of coastal habitat. An estimated 75% of world mangroves have been cleared for coastal development and aquaculture, which has reduced fish nursery habitat, tsunami protection, sediment control, and pollutant processing. And a significant amount of the world's sea grass beds have been destroyed in recent decades.[310]

Each year, thousands of tons of organic pollutants and over 8 million tons of plastics enter the ocean, mainly from river discharge.

Overexploitation – Commercial fishing constitutes one of the largest human impacts to ocean ecosystems.[311] To date, fisheries management still does not adequately consider ecosystem impacts of single-species harvests. Fish catch and consumption increased eight-fold since 1950, and world fishing fleets doubled in size between 1950–2015, from 1.7 million boats to over 3.7 million vessels.[312] Today's fishing fleet has at least twice the capacity necessary to catch total world annual landings. Governments heavily subsidize these fleets with over $50 billion a year. And the problem of illegal, unreported, and unregulated (IUU) fishing is growing.

> *Where resource assessments and monitoring, control, and surveillance and enforcement measures are not available, overfishing and illegal, unreported, or unregulated fishing continues and may be expanding.*
>
> U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[313]

Today, an estimated 93% of all marine fish populations are either overharvested or harvested at maximum yield.[314] As the U.N. recently reported: "The proportion of fish stocks within biologically sustainable levels declined from 90% (1974) to 67% (2015)."[315]

The impact of this level of exploitation on marine ecosystems is unsustainable:

- The global wild-capture fish catch peaked in 1996 at 130 million tons, and has been in decline since, leveling recently at about 93 million tons per year. But some studies suggest that official U.N. world fish catch numbers underestimate total catch by 30%, missing the illegal, under-reported, and other unreported landings;
- Over 50% of the ocean surface is impacted by industrial fishing;
- Today, over 90% of all major fisheries are either depleted, over-exploited, or fully exploited (40 years ago, only 5% were considered as such);
- An estimated 90% of all large fish – e.g., tuna, swordfish, marlin, and sharks – are now gone. And this removal of apex predators has caused a cascade of ecological effects that threaten offshore ecosystems;
- Up to 25% of the annual fish catch is simply discarded as unwanted incidental "by-catch," amounting to 20 million tons per year;
- Each year over 2 billion hooks are set in pelagic longlines, that incidentally kill hundreds of thousands of sea turtles, seabirds, marine mammals, and sharks;
- Bottom trawl gear causes long-term damage to thousands of square miles of seabed habitat each year. As noted marine biologist Sylvia Earl says: "trawling is like bulldozing a forest to catch songbirds";[316]
- Over 100 million sharks are caught each year, a threefold increase over 50 years ago. The population of some species, like white sharks, hammerheads, and oceanic white-tips, has been reduced by over 75% in recent decades. Much of the shark fishery collects only the fins (for the Asian market), and millions of sharks are

Over 50% of the upper ocean is impacted by industrial fishing; 90% of all major fisheries are either depleted, over-exploited, or fully exploited; and 90% of all large fish – e.g., tuna, swordfish, marlin, and sharks – are now gone.

caught, fins cut off, and then released back to the sea to die – a gruesome and inhumane practice;

- World aquaculture production has continued to increase to over 75 million tons (mt) per year (28 mt marine; 47 mt inland), and is now approaching the level of wild fish catch (93 mt total; 81 mt marine; 12 mt inland). But as this production depends heavily on wild forage fish caught for aquaculture feed, it is contributing to depletion of ecologically important wild forage fish populations. And aquaculture can cause serious nutrient pollution in coastal areas;
- The 80 species of whales worldwide have been severely reduced in number due to poorly regulated commercial whaling, now a historic symbol of human greed. Even today, several nations continue commercial whaling, including Norway, Iceland, Denmark's Faroe Islands, and Japan;
- Global seabird populations have declined by 70% since 1950 due primarily to overfishing of their prey, as well as ingestion of plastic debris, incidental take by fishing gear, mortality from rats on nesting habitat, pollution, and climate change. [317]

Deep-Sea Risks - By volume, the pelagic (water-column) deep-sea biome accounts for more than 90% of Earth's biosphere. Although this inaccessible realm (below 1,000 m depth) has long been out-of-sight, out-of-mind for us terrestrial primates, with the rapid development of deep-sea technology, industry now considers the region to be the last, yet most formidable, resource frontier on Earth.[318]

At present, large oil and gas reservoirs are being developed in the deep waters of the Gulf of Mexico, Brazil, East Asia, West Africa, and the Arctic. A dozen state/private mining consortia, interested in mining polymetallic (manganese, iron, copper, and nickel) nodules, have been issued seabed mineral exploration leases across the expansive deep sea Clarion-Clipperton Fracture Zone between Baja Mexico and Hawaii. Companies are interested in mining cobalt-rich ferromanganese crusts on seamounts, and some are poised to begin the first commercial mining (for gold and copper) at deep-sea hydrothermal vents off Papua New Guinea, with other South Pacific nations expected to follow. And there are increasing interests in deep-sea waste disposal (dredge spoil, mine tailings, radioactive materials, and carbon dioxide), commercial fishing, and methane hydrate extraction.[319]

The dangerous combination of increased industrial pressure, high sensitivity to human disturbance, poor scientific understanding, rudimentary management, and virtually no protected areas heralds long-term, potentially irreversible environmental harm to deep-sea ecosystems. To date, there are few protections in place for this vast, remote, and poorly understood biome. And as governments continue to prioritize commercial development over environmental sustainability, the deep-sea biome is being degraded even before we know much about it.

Coral reefs are dying from warmer water temperature, coastal pollution, and overexploitation. Half of the world's coral reefs have been lost since 1870. The U.N. warns that: "Governments should prepare for a dramatic decline (if not a collapse) of coral reef-based industries and ecosystem services."

Seventy-five percent of world mangroves have been cleared for coastal development and aquaculture, with severe ecological effects.

Transportation

The way we transport ourselves has tremendous consequence to the environment. While a billion people still travel mostly on foot, and another 3 billion use mainly bus and bicycle, the automobile has become an iconic symbol of the environmental crisis.

> *With the exception of atomic fission, no other 20th-century technology [than the car] has done more to transform the human species' relationship with the natural world or raised as many troubling questions about reconciling human behavior with the planetary ecosystem.*
>
> MARK HERTSGAARD, WRITER, 1999[320]

The car revolutionized not just human transportation, but also human settlement patterns and industries such as oil, steel, and road construction. There are now over 1.5 billion cars in the world, and this is expected to grow to over 3 billion over the next two decades. This phenomenon has been termed "hyper-automobilization." Cars now consume about a third of the world's oil, and produce 25% of all greenhouse gas emissions, causing billions of dollars in damage to health and the environment each year. The manufacture of cars produces about as much pollution and impact as driving a car.[321] While China had fewer than 2 million cars in 1985, today it has over 300 million.[322]

And we lose significant ecological habitat by building millions of miles of roads and parking lots and by extracting the oil used to fuel these cars. The tragic 2017 flooding from Hurricane Harvey in Texas was partially the result of increased paving of wetlands and fields preventing water from being absorbed naturally. A recent U.N. report predicts that 15.5 million miles of additional roads will be built by 2050, further damaging ecological habitat.[323]

There are now over 1.5 billion cars in the world, and this is expected to grow to over 3 billion over the next two decades.

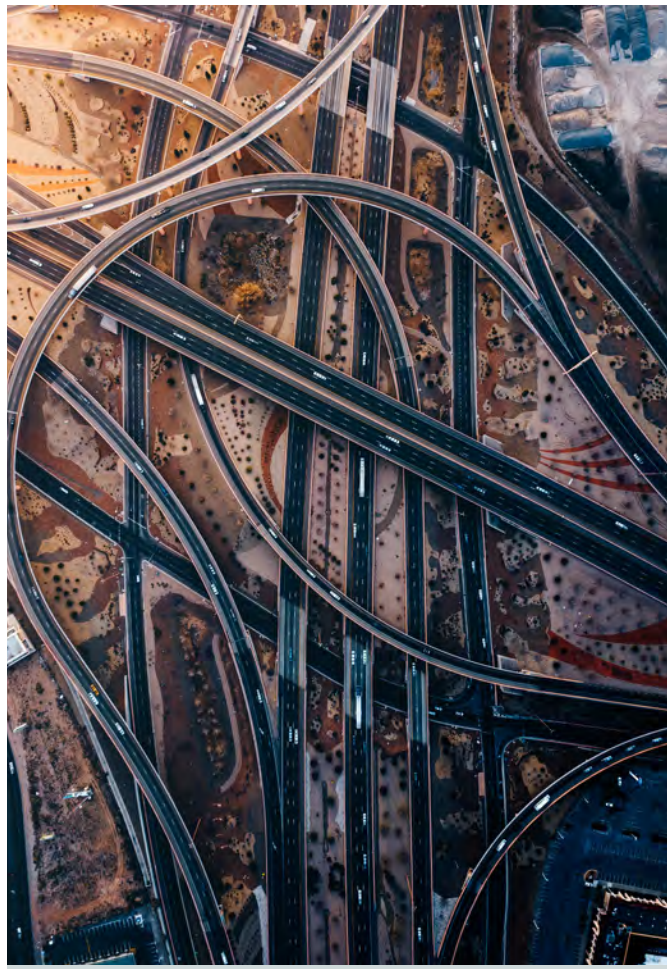
Globally, an estimated 9,300 people die prematurely each day from air pollution from automobiles, and 3,400 people each day (1.25 million per year) die in traffic accidents.[324] Just since 2000 in the U.S., more people have died in car crashes than from both World Wars combined.[325] Traffic jams cost the global economy hundreds of billions of dollars each year in lost productivity. Governments continue to heavily subsidize the automobile through road building and maintenance, police, and health care costs. And now the car has even become a favorite low-cost weapon for terrorists.

While the solution is obvious - build better cars and use cars less - as Mark Hertsgaard notes, building cars is the biggest business in the world, and fueling them is the second biggest industry in the world.[326] Thus, there is overwhelming corporate resistance to more rational, non-automobile alternative transportation policies. While popular ride-hailing companies Uber and Lyft may reduce individual car ownership, they are also competing with urban public transport, leading to greater traffic congestion and increased carbon emissions.[327]

As total passenger miles grow for road and air travel, rail transport has stagnated. This unfortunate transition from rail to road was catalyzed by massive government subsidies promoting the use of the automobile. And air travel has increased 100-fold since 1950, now carrying more than 2 billion people each year. While planes are more fuel-efficient than those 40 years ago, the massive increase in use has increased overall fuel use and impact.[328]

Carhenge.

Cars now consume a third of world oil, produce a quarter of all greenhouse gas emissions, and cause hundreds of billions of dollars in damage annually to health and the environment.



The world now has over 65 million miles of roads, 270 times the distance to the Moon.

Contaminants

Each year some 400 million tons of over 100,000 kinds of synthetic chemicals are produced; most are simply discarded into the environment, where their health and environmental effects are unknown.[329] Over 200 human diseases have been linked to chemical contaminants, including cancers and birth defects. Some chemicals cause endocrine disruption and decreased human sperm counts (perhaps another Gaian response to human overpopulation). Heavy metals cause cancers, developmental disabilities, and autoimmune disorders. Persistent organic pollutants (PCBs, DDT, dioxins, furans, chlordane, and heptachlor) are fat soluble, persistent, transport thousands of miles in air or water, and bio-accumulate in the food chain. Over 350,000 people die each year from acute exposure to chemical contaminants, and all of us have a "body burden" of hundreds of these toxic chemicals. Studies have found dangerous pesticides such as malathion, chlorpyrifos, and 2,4-D in humans eating non-organic diets.

> *Modern society is living in the most chemical-intensive era in human history, the pace of production of new chemicals largely surpasses the capacity to fully assess their potential adverse impacts on human health and ecosystems.*
>
> U.N. GLOBAL ENVIRONMENT OUTLOOK, 2019[330]

And each day, humanity produces over 1 million tons of hazardous waste (sludge, solvents, metals, batteries, asbestos, electrical scrap, plastic, textile waste), mostly in the U.S. The 1989 Basel Convention restricts shipping

Each year some 400 million tons of over 100,000 kinds of synthetic chemicals are produced.

these hazardous wastes from rich to poor nations, but the U.S. hasn't ratified the convention, and now a significant amount is exported to developing nations purportedly for "recycling," but this is more a pretext for landfill disposal.[331]

Pesticide use has increased 10-fold since 1950, and worldwide use is about 3 million tons each year (much of it for lawns and golf courses in rich nations). The World Health Organization (WHO) reports that 3 million people each year suffer from severe pesticide poisoning, and that about 220,000 die.[332] Further, pests are developing resistance to these toxic pesticides, rendering them useless.

Most chemicals are simply discarded into the environment after use, yet scientists have no idea of the effect of most of these on human health or the environment.

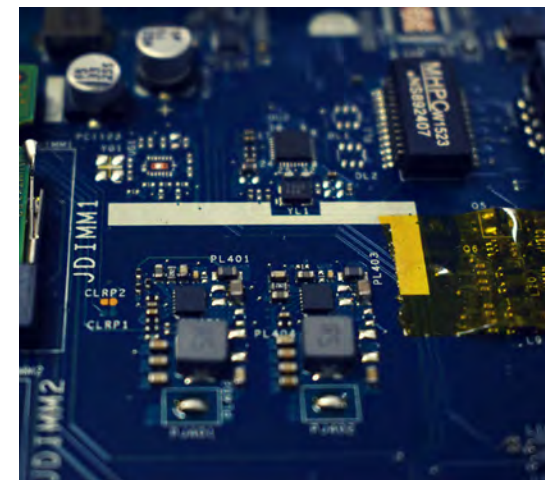
E-waste

Electronic waste ("E-waste") is one of the fastest growing waste streams in the world, now with over 45 million tons generated worldwide each year, including used computers, cell phones, office equipment, and televisions.

Electronic waste ("E-waste") is now one of the fastest growing waste streams in the world.[333] Over 45 million tons of electronic waste is generated worldwide each year, including used computers, cell phones, office equipment, and televisions, and this amount is rising rapidly. Most of this e-waste ends up in landfills, and the rest is shipped to China, India, and Pakistan, where inefficient reclamation techniques are used, and children working to recycle components are exposed to toxic components. Still, the fate of 75% of the world's e-waste remains unknown.

Each year there are 300 million new computers and over 1 billion cell phones produced and sold. These electronics are loaded with hazardous lead, mercury, and cadmium that, when disposed, leach into soil and water and remain for decades.

Dumping of this e-waste is illegal under The Basel Convention (trade in toxics), but the U.S. is the only industrialized nation that has not ratified the Convention. And semi-conductor manufacturing (e.g., in Silicon Valley, California) is one of the most chemically intensive industries known. There are more EPA Superfund sites in Silicon Valley than any other place in the U.S. And electronics companies continue to encourage consumers to replace their computers, smart phones, tablets as often as possible, thus increasing this unnecessary waste stream.[334]



Invasive Species

Each day, hundreds of species of plants and animals disperse across the world through trade, including tanker ballast water, packing material, bulk crop shipments, container ships, aircraft, and tourism. The IUCN Invasive Species Specialist Group list of the 100 worst invasive species includes rats, goats, feral cats, feral dogs, feral pigs, mosquitoes, Asian longhorn beetles, parasitic fungi, cane toads, Caulerpa marine algae, water fleas, termites, carp, zebra mussels, Indian mongooses, Nile perch, Asian gypsy moths, crab-eating macaques, ctenophores (comb jellies), mice, weasels, tilapia, Pheidole ants, American bullfrogs, several trout species, squirrels, blackbirds, brushtail possums, wasps, little fire ants, and many weeds and trees.[335]

These species can become invasive because they are fast growing, have high reproductive and dispersal capacity, and are highly successful at colonizing new ecosystems. Many of these invasive species become dominant and out-compete native species, leading to a cascade of ecological effects – simplified ecosystem structure, reduced biodiversity, altered nutrient cycles, damaged crops and forests, essentially homogenizing ecosystems. Globally, invasive species cause over $300 billion in economic damage each year.[336]

Invasive species are a driver of species extinction and cost the economy billions of dollars each year.

Mining

Each year, billions of tons of material are mined from the Earth's crust, including iron ore, copper, gold, aluminum, platinum, silver, nickel, tin, lead, sand, salt, phosphate, zinc, diamonds, uranium, and Rare Earth Elements (REEs).[337] Today there are an estimated 17,000 large-scale mines in 171 countries, managed by over 600 international corporations.[338]

Material flows from mining, including mined ore and tailings waste, now rival the material flows of all rivers on Earth. And mineral economists now talk of the inevitability of reaching "peak minerals," much as they talk of peak oil. Mining exerts a huge environmental impact through loss of forests and other surface ecological habitats, loss of biodiversity, waste disposal in rivers and coastal seas, failure of tailings dams, toxic contamination (from arsenic, cyanide, sulfuric acid, and mercury), siltation of river systems, and damage to human health.[339] Each year, worldwide mining produces about 90 billion tons of mine waste, with its attendant environmental damage and risk.[340]

Because many land-based ore deposits are in decline, the mineral industry is now exploring deep-sea mineral deposits, including polymetallic nodules on the deep-sea abyssal plain, gold and copper deposits in Seafloor Massive Sulfide (SMS) deposits at deep-sea hydrothermal vents, and cobalt-rich crusts on seamounts. Such deep-sea mining would cause significant and unavoidable environmental damage.[341] And, as with other extractive industries, the mining economy today relies on the waste of its raw materials to create demand for more. The mineral industry consistently resists efforts to move toward closed-loop, circular sourcing of materials in manufacturing, as this would reduce demand for their raw products. Many feel that, if we were to efficiently manage materials, there are already enough mined materials in the economy to eliminate the need to mine more.

Over 17,000 large mines extract billions of tons of material from the Earth's crust and discard over 90 billion tons of waste every year, often with severe environmental impact.

DECLINE OF HUMANITY

It is time to honestly admit that the social integrity of human civilization is unraveling. Social collapse and decay can be seen in many components of society across the world, yet this remains largely invisible to those living within bubbles of affluence in rich countries. Many nations euphemistically called "developing" are actually failing or failed states, and many called "developed" are increasingly unstable.

A few of the disturbing trends are discussed below.

Humanity is now more economically divided than ever before into a small group of "haves" and a large group of "have-nots." The wealthiest 1% of people own more than the other 99% combined.

Rich-Poor Divide

Humanity is now more economically divided than ever into a small group of "haves" and a large group of "have-nots." Wealth and income disparity has increased steadily over the past 40 years.[342] Today, the wealthiest 1% own more than the other 99% combined.[343] Even in the U.S., the wealthiest three individuals own more than the bottom 50% of citizens, and the top 1% own as much as the bottom 95%.[344] This extraordinary wealth disparity results from "winner-take-all" economic policies developed and maintained by the wealthy elite through their self-protective, disproportionate influence on government policy.

A recently proposed "wealth-tax" in the U.S. of 2% on assets over $50 million and 3% on assets over $1 billion, would raise an estimated $275 billion each year from just 75,000 families, less than 0.1% of U.S. households.[345] This would dramatically enhance economic equity, but given the entrenched political power of wealthy elites in America, this may be a difficult policy to enact.

Globally, the consumer rich constitute about 2 billion people, the middle class about 3.5 billion, and the destitute poor about 2 billion living in poverty and privation. Over 75% of the material and energy consumed globally is by the upper 20% in economic class (U.S., Europe, Japan, Canada, Australia/New Zealand), while the bottom 20% account for just 1% of resource consumption. More than 1.3 billion people still lack electric lighting and dependable cooking facilities.

Both rich and poor create serious environmental impacts. The affluent minority consume at unsustainable rates, while the larger and rapidly growing population of disadvantaged people is forced to degrade local ecosystems in order to survive. The growing wealth gap also creates a dramatic divide in health, education and literacy, amplifying the rich-poor divide.[346]

Due to government economic and tax policies advocated by the wealthy elites and corporations, this disparity is growing - the rich are getting richer; the poor are getting poorer. Largely due to income inequality, homicide rates are increasing in Africa, South America, and Asia. Most or the world's poor live in sub-Saharan Africa and South Asia, and most are women. This economic disparity is dangerous, undermines stability and security, and is a ticking socioeconomic time bomb.

The U.N. calls such wealth inequality "grotesque," and such inequality is causing unnecessary environmental stress.[347] With few alternatives, the poor try to support themselves and their families any way they can, often through further environmental degradation. Clearly, economic growth does not necessarily lead to poverty reduction – rather, poverty-reduction is achieved by sharing wealth more equitably.

Third-world debt owed to wealthy nations has now climbed to over $4 trillion. Despite the 2005 Multi-

lateral Debt Relief Initiative in which wealthy nations forgave $50 billion in debt from Heavily Indebted Poor Counties (HIPCs), these developing countries continue to pay over $400 billion each year just to service the interest on their debt.[348] Some countries spend more to service their foreign debt than on education and health care combined, and often raise this capital by causing further environmental degradation – a vicious downward spiral that compromises future ability to service this debt.

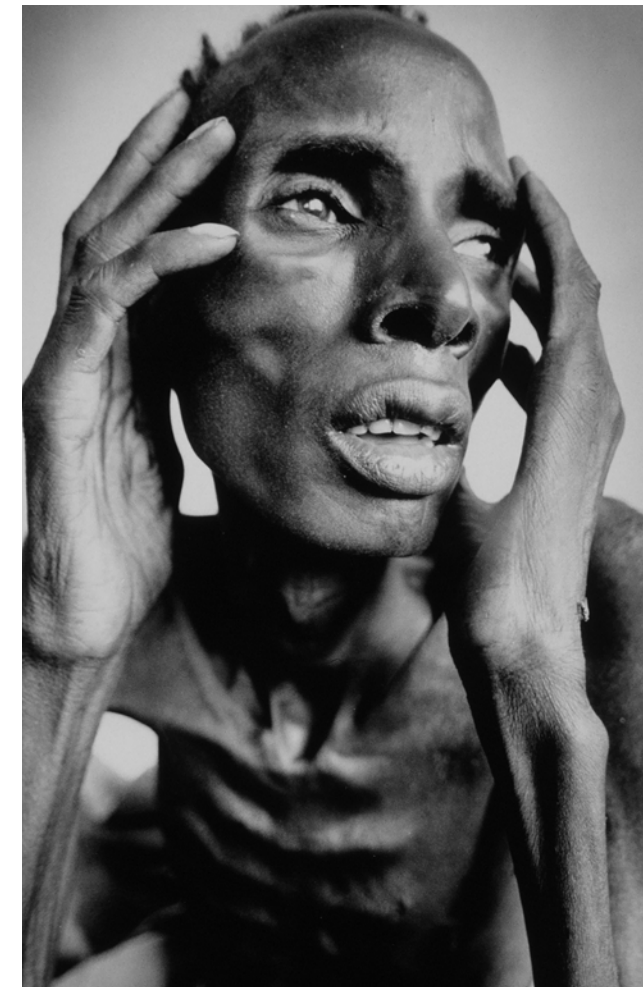
While donor nations pledged at the 1992 Rio Earth Summit to contribute a minimum of 0.7% of their GDP toward Official Development Assistance (ODA) to developing countries, few kept this promise. Today foreign aid from donor nations remains at only about 0.3% of GDP, or a total of about $130 billion per year.[349] Private investment in developing countries is over twice this amount, which leverages government policy in favor of corporate interests and unsustainable industrial development. And governments continue to provide environmentally damaging industrial subsidies in the trillions of dollars each year.[350] In a real sense, the corporation and its investors have supplanted government in running the world.

Humanity is drifting toward a dark, dystopian future.

Refugees flee falling water tables, expanding deserts, sea level rise, crop failures, violence, and flooding in areas where they can no longer survive. Over 30 million people each year are displaced by environmental disasters, and this number is expected to double in the near future.

Environmental Refugees

Environmental refugees flee falling water tables, expanding deserts, sea level rise, crop failures, and flooding in areas where they can no longer survive.[351] Currently, over 30 million people each year are displaced by environmental disasters, and this number is expected to double in the near future. A recent study estimates that climate refugees alone may increase to 1.4 billion by 2060, and perhaps to over 2 billion by end of the century.[352] This will crowd more people onto an ever-shrinking productive land area adding to land and resource conflicts in an already overcrowded world.



Mental Illness and Discontent

The exorbitant material consumption of the Anthropocene has not led to the ubiquitous contentment many had expected. Materialism doesn't satisfy social, psychological, and spiritual needs.[353] Values of integrity, friendship, family, health, and community have atrophied, replaced by a hollow, synthetic, unfulfilling consumer culture. A 2018 "Global State of Emotions" study reports that the global population now is sadder, angrier, and more fearful than ever before.[354]

Increasingly, we are living within a synthetic world fabricated within our own minds, a world of television, computers, smart phones, air-conditioned office buildings, automobiles, concrete and asphalt. Many have observed that we often tend to objectify the world, dividing it into "observer" and "surrounding environment," a place that one is *in*, but not *of.* The basis of eco-psychology is that psychological suffering derives largely from our increasing disconnection with nature. There is growing recognition that "Nature Deficit Disorder" is a powerful cause of growing mental and social dysfunction.[355] And even when many people venture "out" into the natural world, it remains a superficial ego exercise of "trophy hunting" for photo opportunities to post on social media.

> *A civilization which destroys what little remains of the wild, the spare, the original, is cutting itself off from its origins and betraying the principle of civilization itself.*
>
> EDWARD ABBEY, NATURE WRITER, 1966[356]

Far from our rural hunter-gatherer-agrarian ancestry, today there are some 20 mega-cities with over 10 million people, devoid of daily contact with nature. Fanaticism, religious extremism, mass shootings, and terrorism are exacerbated by this disconnect with nature and the psychological stress, inequality, and decline it produces.

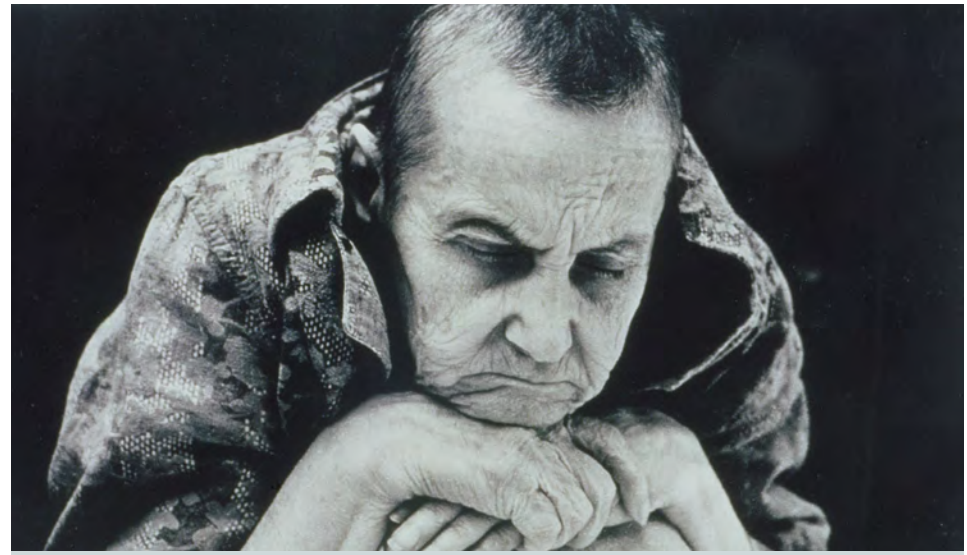
> *Countries like ours are full of people who have all the material comforts they desire, yet lead lives of quiet (and sometimes noisy) desperation, understanding nothing but the fact that there is a hole inside them and no matter how much food and drink they pour into it, however many motor cars and television sets they stuff it with, however many well-balanced children and loyal friends they parade around the edges of it…it aches.*
>
> BERNARD LEVIN, PHILOSOPHER, 1990[357]

On the one hand, in the "developing" world - where hundreds of millions live in severe poverty, and lack access to health care, economic opportunity, and upward mobility – discontentment, despair, mental illness, alienation, and a sense of hopelessness are systemic.

On the other, the "developed" world is experiencing an equally pernicious mental health crisis. In many industrialized countries, overall social and mental health

has been in decline for decades from depression, aggressive behavior, drugs, teen suicide, school dropouts, gang violence, chronic disease, and political disengagement.

The U.N. World Health Organization (WHO) estimates that 500 million people (in all nations, of all backgrounds) have a mental or neurological disorder - depression, schizophrenia, substance abuse, eating disorders, sleep disorders, bipolar disorder, panic and anxiety disorders.[358] Depression is perhaps the most debilitating, with an estimated 300 million cases worldwide. Globally, over 2,000 people a day commit suicide (800,000 per year), and 20 times that number attempt it.[359] Antidepressant pharmaceutical sales have skyrocketed, increasing over 60% in just the past decade. In the U.S. alone, there are now over 100 million antidepressant and opioid prescriptions written each year.



The 2018 "Global State of Emotions" report concludes that the world population now is sadder, angrier, and more fearful than ever before.

As noted above, accumulation of wealth beyond levels needed for basic subsistence has become an addiction in the affluent West, and has led to discontentment rather than wellbeing. Consumerism creates feelings of emptiness or incompleteness, and fuels our desire to fill these emotional holes with outside substances and products. As economist Philip Slater notes, this is the very essence of addiction. Slater concludes that one of the main reasons excessive wealth makes people unhappy is that it gives them too much control over what they experience; they try to project their own fantasies onto reality, instead of experiencing what unfiltered reality itself presents. In essence, excessive financial wealth gives the human ego too much power, removes necessity, and leads to emotional decline.[360]

There is a beautiful subtlety to our relationship with nature and necessity, a fine reciprocity: we play with necessity, it teaches us. We learn capacities and depths in ourselves we never knew we had. We learn joys in the world we never knew existed.

PHILIP SLATER, ECONOMIST, 1980[361]

Excess wealth restricts this "fine reciprocity" with nature and necessity, leaving us bereft and joyless. Renunciation of the trappings of wealth in the Western world gave rise to the "voluntary simplicity" movement, a notion that leads not only to greater contentment, but also to the reduction of one's ecological footprint.

Social and mental health has been in decline for decades. The World Health Organization estimates there are 300 million cases of depression worldwide, 2,000 people a day commit suicide (800,000 per year), and 20 times that number attempt it.

"Nature Conservation Area."

Corruption

A persistent impediment to a sustainable economic/environmental transition is political corruption, as it weakens democratic institutions and rule of law, costs the economy trillions of dollars each year, and enables environmentally destructive projects and policies that otherwise would be unacceptable.

By maintaining the flow of wealth to criminal elites, corruption continues to deprive communities of economic equality and forces them into various forms of detrimental, unsustainable activity. International crime syndicates now control trillions of dollars in assets, costing the global economy an estimated $870 billion per year (many times the total annual foreign aid budgets).[362] The extraordinary influence these organized crime syndicates exert over political processes is an enormous barrier to sustainability and environmental protection.

As detailed by Transparency International:

Corruption is the abuse of entrusted power for private gain. It can be classified as grand, petty, and political, depending on the amounts of money lost and the sector where it occurs. Grand corruption consists of acts committed at high levels of government that distort policies or the central functioning of the state, enabling leaders to benefit at the expense of the public good. Petty corruption refers to everyday abuse of entrusted power by low-level and mid-level public officials in their interactions with ordinary citizens…Political corruption is a manipulation of policies, institutions, and rules of procedure in the allocation of resources and financing by political decision makers, who abuse their position to sustain the power, status, and wealth.

Economically, corruption depletes national wealth. Corrupt politicians invest scarce public resources in projects that will line their pockets rather than benefit

communities, and prioritize high-profile projects such as dams, power plants, pipelines, and refineries over less spectacular but more urgent infrastructure projects such as schools, hospitals, and roads. Corruption also hinders the development of fair market structures and distorts competition, which in turn deters investment.

Corruption corrodes the fabric of society. It undermines people's trust in political and economic systems, institutions, and leaders. It can cost people their freedom, health, money – and sometimes their lives.

Environmental degradation is another consequence of corrupt systems. The lack of, or non-enforcement of, environmental regulations and legislation means that precious natural resources are carelessly exploited, and entire ecological systems are ravaged. From mining, to logging, to carbon offsets, companies across the globe continue to pay bribes in return for unrestricted destruction.

TRANSPARENCY INTERNATIONAL, 2019[363]

Corruption manifests as bribery, money laundering, fraud, and public officials using office for personal gain. It weakens environmental oversight and makes a country more vulnerable to conflict. There is a corruption component behind many environmentally destructive projects.

The annual economic costs of corruption are estimated at 5% of world GDP, or about $2.6 trillion each year.[364] The World Economic Forum estimates that businesses and individuals pay more than $1 trillion each year in bribes.[365] A recent U.N. study estimates that over 30% of freight transport costs worldwide go to pay bribes along major transportation routes.[366]

And corruption has a direct relationship to conflict; it fuels conflict, and thrives from it. As well, *legal* corruption, where commercial institutions (e.g., corporations) unduly influence public policy for their self-interest, is a significant impediment to environmental progress.

Today half of all people live in cities. By 2050, two-thirds of all people (7 billion out of 10 billion) will live in cities, mostly in low-income countries. The urban slum has become a quintessential symbol of the decline of modern civilization.

Urbanization

Urbanization is one of the dominant demographic trends of the past century and will continue throughout this century.[367] While in 1900 only about 10% of the world population lived in cities, today over 50% of all people live in cities. The U.N. predicts that by 2050, two-thirds of all people (6.7 billion of a total population of 9.7 billion) will live in cities. About 90% of the future growth in urban areas will occur in low-income countries, largely due to migration.[368] Each year, over 70 million people are added to urban populations, and most urbanization has been poorly planned with respect to flood and earthquake resilience and socio-economic needs. Some 60% of the infrastructure needed to accommodate the urban population of 2050 has yet to be built, and this offers an opportunity to design long-term environmental sustainability into urban planning.

Cities cover only about 3% of the Earth's land surface but account for 70% of global energy consumption and carbon emissions. Globally, there are now 31 mega-cities with over 10 million people in each. Urban population is expected to increase by another 1.5 billion by 2030, and 2.5 billion by 2050 (mostly in Asia and sub-Saharan Africa).[369]

The urban slum has become a quintessential symbol of the decline of modern civilization. As many rural people move to cities seeking economic and social opportunity, they often encounter extreme poverty, wealth disparity, economic exclusion, unhealthy living conditions, and marginalization. Today, one billion people live in urban slums, a number that is expected to increase significantly.[370] These slums are characterized by lack of clean drinking water or sanitation, disease (e.g., HIV and cholera), overcrowding, makeshift living structures, high childhood mortality, short life spans, the lowest literacy rates in the world, and lack of secure property tenure. The U.N. predicts that by 2050, from 2–3 billion people will be living in "informal settlements" in cities, characterized by inequality, crime, social and economic exclusion and deterioration.[371]

Violence Against Women

Millions of women in the developing world continue to suffer female genital mutilation (140 million women worldwide); forced malnutrition; incest; denial of medical care, education, and employment; forced marriage; rape; prostitution; forced labor; and violence and murder.[372] Each year, millions of girls and women are bought and sold by organized criminal cartels and are often forced into prostitution. Global suicide rates are highest among oppressed women. Female infanticide remains epidemic in some regions. Millions of girls have "disappeared" from south and East Asia (Afghanistan, Pakistan, India, Bangladesh, and China), likely the result of infanticide.[373]

Slavery

Today there are an estimated 45 million people in slavery worldwide, more than at any previous time in human history.[374] While slavery is illegal the world over, it is also big business, generating over $150 billion a year for traffickers. Slavery includes forced labor, debt bondage, human trafficking, forced marriage, and sex slavery. Causes for the resurgence in slavery include the rapidly expanding population in developing countries, increased poverty, migration from rural to urban areas in search of jobs, government corruption, social inequality, and discrimination. The enslaved today consist of 78% in labor slavery and 22% in sex slavery (forced into prostitution), of which a quarter

are children. Labor slavery includes fishermen, farmers, miners, brick makers, maids, gardeners, and dishwashers. Over 4 million people today are in labor forced by government authorities.

Slave markets in Libya came to world attention in 2017, where refugees from Nigeria, Senegal, and Gambia are captured by criminal gangs and sold for $200 - $500 each.[375] Thousands of young women are trafficked for sex slavery each year from Nigeria to Europe, and the trafficking rate doubled from 5,000 women in 2015 to over 11,000 in 2016.[376] Nigeria's anti-trafficking agency reported recently that some 20,000 Nigerian girls, lured by human traffickers promising legitimate employment in Southeast Asia, have been forced into prostitution in neighboring Mali.[377] The rise in slavery highlights a troubling breakdown in the social welfare network of civil society in much of the world.

Homo sapiens *is one of the most violent animals on Earth. Last century over 130 million people were killed in war, and 210 million were killed if including government killings in non-war situations. Dozens of armed conflicts occur each year, and many have a resource component, such as diamonds, gold, oil, timber, water, or grazing land.*

Conflict and War

Intraspecific violence in the animal world is certainly not limited to humans, but our species has taken this to a barbaric extreme. While some other mammal species kill one another (lemurs, hyenas, mongooses, wolves, bears), most mammal species are not known to do so.[378] By any measure, *H. sapiens* is one of the most violent animals on Earth.

While the per-capita *rate* of human-on-human violence may have been higher in medieval times, the *total number* killed was higher in 20th century than at any other period in history, with over 130 million people killed in war, and 210 million killed when including government killings in non-war situations.[379]

After WW II, the enormous conversion of domestic industries to defense industries in the U.S. took on a life of its own and continued to expand. Former U.S. President Dwight D. Eisenhower warned in his 1961 farewell address to the nation:

> ***In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist.***[380]
>
> PRESIDENT DWIGHT D. EISENHOWER, 1961

Unfortunately, this warning went largely unheeded, and the momentum of the military-industrial complex continued. Today, global military expenditures continue to rise, now between $2 trillion to $3 trillion a year (about

40% of this in the U.S. alone), compared to just $5 billion spent for U.N. peacekeeping.[381] Just in the past 15 years, the financial cost of war has exceeded $13 trillion.[382] Post - 9/11 wars alone have cost the U.S. $5 trillion and thousands of lives. Today there are over 20 million serving in armed forces globally, and from 100,000–300,000 children (age 7-16) are at war. International arms transfers amount to over $150 billion each year, mostly from the U.S. The arms trade is big business, giving manufacturers a mercenary incentive to perpetuate conflict.

Global military expenditures now total 2 to $3 trillion a year, compared to just $5 billion for U.N. peacekeeping.

Dozens of armed conflicts occur each year, and many have a resource component, such as diamonds, gold, oil, timber, water, or grazing land. In Darfur, Sudan, 2 million died largely in a land conflict between Arab herders and black African subsistence farmers. In the Congo, 5 million died in conflict over gold and coltan (used for cell phones). In Rwanda, population increased from 2 million in 1950 to 8 million in 1993, becoming the most densely populated country in Africa. Farming could not keep up with food demand and starvation increased, culminating in the 1994 genocide that killed 800,000 people in just three months.[383]

Water shortages, desertification, crop failure, flooding, and overcrowding all contribute to conflict, and these stressors are all expected to grow in the future. There are now over 500 million military assault weapons in circulation, and illicit arms sales exceed $5 billion a year. The world seems now to be in perpetual conflict and war.

In addition to its humanitarian toll, war also causes serious environmental degradation, including massive oil spills, wildfires, toxic contamination, forest loss, and lost access to arable land from unexploded ordnance and landmines remaining post-conflict.

And intentional deaths by homicide increase every year. Today more people die from homicide than from conflict and terrorism combined. In 2017, armed conflict killed 89,000, terrorism killed 26,000, and intentional homicide killed 464,000.[384]

In the digital age, conflict has taken a new dimension through clandestine use of social media and false information against adversaries. A notable example was the intentional Russian interference in the 2016 U.S. presidential election in order to favor the Russian government's preferred candidate, who was then elected. Without a shot fired, one world superpower changed the course of history of its chief rival and, indeed, that of the world.

The "forever war" continues, with no end in sight.

Landmines

Today there are an estimated 50 million antipersonnel landmines in the ground around the world that continue to kill and injure more than 4,000 people each year, many of them children, and mostly in countries no longer at war.[385] When explosive remnants of war (e.g., unexploded ordnance) are counted, the total number in the ground today is approximately 110 million.[386] Most of the landmines today are in Egypt, Angola, Iran, Afghanistan, Iraq, China, Cambodia, Mozambique, Bosnia, Somalia, Eritrea, and Sudan, but 85% of the landmine casualties each year are in Egypt, Angola, and Iran.

In addition to their direct humanitarian toll, landmines keep vast areas of arable land inaccessible and inhibit travel and commerce. Most mines have been laid in agricultural fields, forests, around water sources, and power sources, rendering them unusable, or usable only at high-risk.

Since the 1997 International Mine Ban Treaty (signed by 162 nations), production and use has dropped sharply, more land has been cleared of mines, stockpile destruction has continued, and there have been fewer victims. But there are over 50 treaty holdouts, notably the U.S., Russia, and China. There are still 250 million mines in stockpiles (mostly in China). At current clearing rates, even with no new mines laid, it will take more than 1,100 years to clear all the landmines globally.[387]

There are now 30 to 60 failed states affected by weak governance, conflict, and violence, with over 2 billion people. These states are dangerously unstable, and prone to international security threats including terrorism, weapons proliferation, organized crime, infectious disease, environmental degradation, and cross-border conflict.

Fragile and Failed States

Today, over 2 billion people live in countries affected by fragility, weak governance, conflict and violence.[388] Fragility is generally measured with metrics for economy, politics, security, social welfare, and per capita income. Fragile and failed states are dangerously unstable, and prone to international security threats including terrorism, weapons proliferation, organized crime, infectious disease, environmental degradation, and cross-border conflict.[389] The percentage of poor people living in failed states is expected to rise from 17% today to 46% by 2030. Today, the developed world is threatened not so much by conquering states, but by failed states. There are an estimated 65 million refugees from violence globally, almost all from failed states.

Estimates of the number of failed states today range from 30 to 60. These include Ivory Coast, Congo, Syria, Sudan, Iraq, Somalia, Sierra Leone, Chad, Yemen, Liberia, Haiti, Afghanistan, Rwanda, and Colombia; major oil producers - Saudi Arabia, Russia, Venezuela, Indonesia, and Nigeria; and three nuclear weapons states - Russia, Pakistan, and North Korea.[390] Again, while the international community calls these "developing" nations, they are more often failing, highly unstable, or failed states.

The main indicators of state fragility and failure include loss of governmental legitimacy; failing public services; breakdown in rule of law; overpopulation; emigration; high unemployment; uneven development; violence and armed gangs; rise of warlords; deteriorating infrastructure; tribalism; corruption; and religious extremism. Such states are refuges for terrorists, drugs, weapons, and human trafficking. Some are perpetually on the edge of erupting in armed conflict. Life expectancy is now less than 50 years in some failing countries.

Most of today's international terrorism derives from radicalized groups in fragile and failed states.[391] Three fragile and failed states are listed by the U.S. State Department as state-sponsors of terrorism: Syria, Iran, and Sudan. And insecurity, conflict, and terrorism deriving from these unstable regions diverts attention and resources from the urgency of global ecological collapse.[392]

Nuclear Weapons

Finally, one of most troubling aspects of modern civilization is the development and threatened use of nuclear weapons. In addition to environmental collapse, nuclear war may represent another "Great Filter" threshold (discussed in Section II) beyond which civilization will not survive. Particularly disturbing is the notion of Mutually Assured Destruction, or "MAD," in which deterrence to nuclear attack is the assurance of a full-scale counterattack and destruction of both sides. Winston Churchill once famously commented: "If you go on with the nuclear arms race, all you are going to do is make the rubble bounce."[393]

In addition to the direct risk to hundreds of millions of human lives, some scientists feel that full-scale nuclear war poses one of the greatest threats to the global environment today. The indirect environmental effects of full-scale nuclear war put at risk much of human civilization and the biosphere.

Studies estimate that firestorms from a nuclear war detonating 100 Hiroshima-sized warheads (18 kilotons) would suspend 5 million tons of black soot (elemental carbon) into the upper atmosphere, causing abrupt and unprecedented climate impacts, including "nuclear winter" with global cooling of about -1.25°C, reduced precipitation, damage to the stratospheric ozone layer, reduced photosynthesis, and years of crop failure and famine.[394]

For decades, human civilization has teetered on the edge of thermonuclear annihilation and this threat continues. Today, there are nine nuclear weapons states. While the global nuclear arsenal peaked at 70,300 warheads in 1986, it has now declined to about 13,850 today, with 6,490 in Russia, and 6,185 in the U.S.[395]

The reduction in nuclear weapons over the past 30 years is one of the greatest successes in the history of

One of most troubling aspects of modern civilization is the development and threatened use of nuclear weapons. In addition to the direct risk to hundreds of millions of human lives, some scientists feel that full-scale nuclear war poses one of the greatest threats to the global environment today.

international diplomacy. But with thousands of these weapons still targeted or readily available for use, grave risk remains. As the Nuclear Threat Initiative (NTI) warns: "That's enough to destroy the planet hundreds of times over."[396]

Of the remaining global total, about 5,600 warheads are withdrawn and waiting to be dismantled, leaving over 8,000 available, ready to use, in military arsenals. And the global nuclear arsenal today is far more lethal than 50 years ago, with a combined yield of about 6,500 megatons (million tons), more than 360,000 times the yield of the Hiroshima detonation. Of greatest concern, some 2,000 of these nuclear weapons are deployed and targeted, on hair-trigger alert, and ready to be launched within minutes. India and Pakistan, two nuclear states, continue in conflict over the border of Kashmir, raising the possibility of nuclear war in South Asia. North Korea, an unstable dictatorship, is the newest nuclear weapons state, now with an estimated 20 nuclear weapons, due mainly to technology sold illegally to it by Pakistani nuclear scientist A.Q. Khan.

In early 2019, both the U.S. and Russia announced they would abandon the landmark 1987 Intermediate Range Nuclear Forces (INF) Treaty that had restricted medium-range (300 mile–3,000 mile) nuclear missile deployment in Europe.[397] The U.S. and NATO accused Russia of repeatedly violating the treaty by deploying many of its medium-range 9M729 ballistic missiles capable of striking targets in Europe and Asia. If launched, these medium-range missiles would only take a few minutes to reach targets, leaving virtually no time to respond. Thus, even a false launch warning could trigger a global nuclear exchange. The abandonment of the INF treaty raises concerns over a new cold war between the two nuclear states.

Risk of Accidents - As the U.S. and Russia keep some 2,000 nuclear weapons actively deployed and on hair-trigger alert, accidental launch remains a very real threat.

> *Despite the most elaborate precautions, it is conceivable that technical malfunction or human failure, a misinterpreted incident or unauthorized action, could trigger a nuclear disaster or nuclear war.*
>
> U.S./SOVIET ACCIDENT MEASURES AGREEMENT, 1971[398]

False alerts and near misses happen with surprising frequency.[399] In 1983, the Soviet military confused satellite detection of light reflected from clouds for what they took to be five incoming nuclear missiles, and came within minutes of ordering a retaliatory launch. In 1995, the Russian military confused a research rocket launch from Norway for a U.S. submarine ballistic missile launch, and made preparations for full-scale nuclear response. President Yeltsin dialed up the launch codes but ultimately realized it was a false alarm.

The U.S. has had dozens of near-miss nuclear weapons incidents. In 1961, two armed thermonuclear bombs dropped in North Carolina when a B-2 bomber broke up in-flight, and one of the bombs came close to detonation. In 1962, at the height of the Cuban missile crisis, a training tape simulating a Cuban missile launch was run at a radar tracking facility, and NORAD was (falsely) alerted that an attack was underway. In 1968, a

B-2 bomber with four nuclear weapons crashed near Thule Greenland contaminating the area with plutonium. In 1979, a technician accidentally inserted a training tape with a scenario of a large-scale Soviet missile attack into the operational computers at NORAD, and the entire U.S. nuclear defense apparatus went on high alert. And in 2003, half of the Air Force nuclear weapons safety and security units failed a planned safety inspection. These are just the serious safety lapses we know about.[400]

And on August 8, 2019, an experimental Russian nuclear-powered SSC-X-9-Skyfall cruise missile exploded while being tested on an offshore rig in the Russian artic, killing at least 5 workers, and exposing locals to elevated levels of radioactivity.[401]

"Loose Nukes" – Many nuclear warheads and much nuclear material remains vulnerable to theft or black market sale for terrorist acquisition. Just 15 pounds of plutonium is enough to make a Hiroshima-strength bomb, and there are thousands of pounds of plutonium and highly enriched uranium scattered around the former Soviet states. In 1997, U.S. agents in Miami were offered nuclear weapons by smugglers, and at least six cases of stolen nuclear materials from Russia have been intercepted. The question remains as to how many such sales were not intercepted. Many Russian nuclear facilities remain poorly secured.[402]

Weapons Production Impacts – The former USSR's Mayak nuclear weapons production site in Chelyabinsk suffered some of the largest nuclear disasters in history, but these were kept secret by the Soviet government at the time.[403] In the first, from 1949–1956, nuclear waste was intentionally dumped into the Techa River, flowing into the Ob River and the Arctic Ocean, exposing thousands of people downstream. In the January 1957 Kyshtym disaster, one of the worst nuclear disasters in history, the nuclear waste storage dump exploded, releasing 50–100 tons of high-level radioactive waste into the air, contaminating several thousand square miles of the region.[404] And in 1967, the facility intentionally dumped radioactive waste into nearby Lake Karachay. The lakeshores dried up, and wind blew radioactive dust (Strontium 90 and Cesium 137) over 20,000 mi² of the densely populated East Ural Mountains. Countless radiation-induced sicknesses and deaths have resulted from these incidents. Attempting to conceal the disaster from the outside world, in 1968 the East Ural Radioactive Trace (EURT) area was designated by the Soviet government as the "East Ural Nature Reserve," and access remains restricted today.

The U.S. nuclear weapons facility on the Columbia River at Hanford, Washington produced plutonium for nuclear weapons from 1947-1987.[405] During operation, the facility continually released radionuclides to the air and into the Columbia River, which then traveled downstream to the Pacific. After closing, the facility left behind over 50 million gallons of high-level radioactive waste in leaking storage tanks, and 25 million cubic feet of solid radioactive waste, which contaminated groundwater over hundreds of square miles. The U.S. government is now conducting a multi-billion dollar clean up, but it is doubtful the site can be entirely cleaned and restored.

After the 2016 U.S. election, the *Bulletin of Atomic Scientists* moved its "Doomsday Clock" to within 2 minutes and 30 seconds of midnight, the closest to midnight since 1953 after the U.S. tested the first hydrogen bomb.[406] Despite decades of successful nuclear arms reductions, President Trump called for a multibillion-dollar "modernization" of the U.S. nuclear arsenal, suggested other countries should obtain nuclear weapons, and declined to rule out first-strike use of nuclear weapons. Mr. Trump's statements give pause: "Let it be an arms race. We will outmatch them at every pass, and outlast them all"; and "If we have nuclear weapons, why can't we use them?"; and that any threat from North Korea will be met with "fire and fury."[407]

If one connects the dots between the above trends in population, resource depletion, extinction, deforestation, agriculture, water stress, pollution, energy, climate, oceans, transportation, wealth inequality, mental illness, failed states, and nuclear proliferation, prospects for securing a sustainable future seem remote.

Indeed, the global crisis is growing, but as many have noted, in crisis lies opportunity. As discussed in Section IV, if we act boldly, decisively, and quickly, a sustainable future is still within reach. ●

While the global nuclear arsenal peaked at 70,300 warheads in 1986, it has now declined to about 13,850 today, with 6,490 in Russia, and 6,185 in the U.S., the rest in the other seven nuclear weapons states. The reduction in nuclear weapons over the past 30 years is one of the greatest successes in the history of international diplomacy. But with thousands of these weapons still targeted or readily available, grave risk remains. As the Nuclear Threat Initiative warns: "That's enough to destroy the planet hundreds of times over."

IV

PARADISE RESTORED:

Solutions for a Sustainable Future

Never before have we been so aware of what we are doing to the planet – and never before have we had such power to do something about it.

DAVID ATTENBOROUGH, NATURALIST AND BROADCASTER, 2017[408]

So, has biological evolution temporarily lost its way, in this back-eddy of the self-interested, self-destructive, pleasure-seeking monkey-mind? Or perhaps break*down* is necessary before break*through*? We have proven that we are smart enough to provide for ourselves, but we have yet to prove that we are smart enough to do so without simultaneously destroying the planetary environment. What is certain is that the stage is now set for the next chapter in this remarkable history of the evolution of life on Earth.

Given the facts presented in Section III, it is easy to feel overwhelmed or resigned to the conclusion that there is little hope to save the future of Earth's biosphere. Indeed, if current environmental trends continue, the planet will be virtually unlivable for humans and perhaps half of all other species by 2050, certainly by 2100. For many people and other species, in many places, it already is. We are a civilization in collapse, and we are destroying much of the biosphere on our way down.

The Earth was small, light blue, and so touchingly alone, our home that must be defended like a holy relic.

ALEKSEI LEONOV, RUSSIAN COSMONAUT, 1975[409]

Despite all of the effort since the first Earth Day in 1970 to redirect this trajectory, we are still heading over an ecological cliff. Our collective efforts may have slowed the decline, but we haven't halted or reversed it. Again, we know the causes, we know the consequences, and we know exactly how to solve it, yet we have yet to do so.

For some reason, we seem transfixed, almost hypnotized by the crisis. We continue to reiterate and restate the problem, but fail to take the action necessary to solve it. Indeed, we seem stuck in what could be called the "Doing Good Insufficiently" paradox: we are doing many good things for the environment, but collectively they have been insufficient to stop or reverse overall environmental decline. And paradoxically, while we assume this is sufficient, it isn't.

Governments, industry, and much of the public proceed as if the current course will continue indefinitely. It can't. This is an historic, dangerous delusion. One can imagine the people of Rapa Nui (Easter Island) suffering the same pre-collapse delusion.

As the Dalai Lama has said: "Change only takes place through action…not through prayer or meditation, but action."[410] If we don't make bold changes immediately, the only question left will be how and when civilization will collapse, and what will be left of the biosphere. By many measures (as discussed in Section III), civilization has already begun to implode. This is indeed an historic turning point in human history.

We went to the Moon as technicians. We returned as humanitarians.

EDGAR MITCHELL, APOLLO 14 ASTRONAUT, 1971[411]

As stated in the Introduction, this decade (2020-2030) will be the most critical existential moment in the history of our species – either we will fix these interconnected environmental problems now, or we will not survive long into the future. We are truly out of time. It is still possible to fix this crisis, but we absolutely must take transformative action immediately.

Fortunately, we know exactly what we need to do to solve this crisis, restore the Earth, and put civilization on a sustainable path, as discussed in this section.

The best way to predict the future is to invent it.

DENNIS GABOR, PHYSICIST AND NOBEL LAUREATE, 1963[412]

This decade (2020 - 2030) will be the most critical existential moment in the history of our species. Either we will fix these interconnected environmental problems now, or we will not survive long into the future. The decade will be breakdown or breakthrough.

If humans want to be part of the sustainable Ecocene, we know exactly what we need to do by 2030: reduce global carbon emissions by 50%; stabilize human population; halt destruction of ecological habitat; place half of the Earth's lands and waters in protected status; reduce extinction rates to the pre-human background level; shift to a zero-waste, circular economy focused on stability and equity rather than growth; shift to sustainable, low-impact agriculture; significantly reduce wealth disparity and poverty; provide education, heath care, and economic opportunity for all; eliminate all nuclear weapons; and transition from an Anthropocentric to an Ecocentric worldview.

Government

While personal action to reduce our individual ecological footprint is necessary, this alone will not solve a crisis at the scale and pace necessary. Green consumerism, while helpful, remains largely a choice reserved for affluent consumers. No matter how responsibly wealthy consumers behave, the biosphere will continue to decline. Similarly, Corporate Social Responsibility (CSR) efforts are necessary and useful, but they alone will be insufficient. In the end, solving this crisis will take a coordinated, synergistic approach led by government.

We need governments to restructure the global economy; refocus economic policy from continuous growth to stability; stabilize population; reduce resource consumption; transition to sustainable energy and food producing systems; equitably distribute wealth and resources; achieve a zero-waste society; and protect ecological habitat.

> *Growth for the sake of growth is the ideology of the cancer cell.*
>
> EDWARD ABBEY, NATURE WRITER, 1977[413]

Environmental decline can be reversed only through strong, cohesive government action, where governments exercise their authority to *tax, spend/subsidize, regulate, and enforce* (TSRE). On this, there are five urgently needed macroeconomic policies governments must adopt: (1) Forgive debt of developing countries; (2) End perverse subsidies; (3) Tax unsustainable activities; (4) Apply additional revenues from taxes and subsidy elimination to sustainability measures; and (5) Regulate and enforce environmental protection.

Debt Relief – All foreign debt that is owed to wealthy governments and international financial institutions by Heavily Indebted Poor Countries (HIPCs) should be forgiven, with the stipulation that in exchange for such debt relief, the debtor governments agree to adopt basic principles of human rights, environmental protection, transparency, audit of revenues, and strong anti-corruption measures.

Eliminate Perverse Subsidies – Governments today pay trillions of dollars each year to subsidize environmentally damaging fossil fuels, roads, nuclear energy, deforestation, and grazing and water use/waste.[414] Effectively, we are subsidizing our own destruction, which is exceptionally irrational. All countries should transfer perverse subsidies to support sustainability, in particular to energy efficiency, renewable energy, and sustainable agriculture.

Environmental Taxes - All nations should identify and impose substantial new taxes and royalties on unsustainable business activities, in particular a carbon tax on fossil fuel/greenhouse gas emissions, and taxes on unsustainable forestry, agriculture, fisheries, waste and transportation systems. At a minimum, this should include an additional 10% tax/royalty on all coal and oil production to begin capturing real costs, including health care, air pollution, climate change, and habitat loss.

Financing Sustainability – To save the world, we need to pay for it. Every dollar we invest in sustainability today will return many times the financial benefit in the future. Put simply, our future is a good investment. All revenues accrued through new environmental taxes and

subsidy shifts (above) should be applied both domestically and internationally to support the urgent transition to sustainability. Wealthy nations (the largest economies) of the world – the Group of Twenty (G20) – produce over 80% of world GDP and trade, over $60 trillion per year.[415] Over the next critical 10 years, G20 governments should commit no less than 5% of their annual budgets to domestic environmental spending. Internationally, the G20 governments must at least make good on their commitments made at the 1992 Rio Earth Summit to provide 0.7% of GDP in Official Development Assistance (ODA).[416] Shamefully, few have kept this promise. If the G20 governments were to make good on their Rio commitments to foreign aid, this would provide roughly $500 billion annually.

But given the scale of the global environmental emergency we face, the amount of funding needed now for international environmental assistance is roughly $1 trillion per year, with another $1 trillion needed for socioeconomic sustainability. The $2 trillion per year emergency environmental and socioeconomic funding, a "Living Planet Emergency Fund" over the next 10 years, would be roughly equal to annual global expenditures for military, advertising, or entertainment.

The Living Planet Emergency Fund would easily cover the previously promised $100 billion a year "Green Climate Fund" that today remains an elusive goal. The benefit/cost of this investment is perfectly clear, and should be persuasive. For instance, just on climate mitigation, Project Drawdown estimates that its "Plausible Scenario" would have a net cost of $27 trillion while providing a net savings of $74 trillion – more than a two-fold benefit.[417] There is similar benefit/cost of investing today in all environmental sustainability measures discussed here. We pay for what we value, and the longer we wait to make this investment in our sustainable future, the more costly and less achievable it will be.

Solving this crisis will take a coordinated approach led by government.

The $2 trillion per year Living Planet Emergency Fund could be derived from a 3% assessment on the G20 nations' GDP over the next 10 critical years, and managed by the U.N./World Bank "Global Environment Facility" (GEF). Alternatively, revenue could be obtained by instituting a "wealth tax" as currently proposed in the U.S. As proposed, a 2% tax on all personal assets over $50 million, with an additional surcharge of 1% on assets over $1 billion, would generate approx. $275 billion a year in additional revenue to the U.S. government.[418] Another model would be a "Robin Hood Tax" ("Tobin Tax"), assessed on all financial trades of stocks, bonds, and derivatives. Alternatively, these funds can be raised by reallocating environmentally damaging subsidies currently paid by governments, now totaling more than $5 trillion each year. Such mechanisms could provide a substantial amount of the global environmental funding necessary over the critical next decade, and at the same time reduce wealth disparity and its accompanying social ills.

This increased financial assistance from the world's major economies should be made available immediately for environmental protection and restoration, including forest conservation and restoration, soil and rangeland conservation, freshwater conservation, ocean protection, biodiversity conservation, and the socioeconomic goals agreed by world governments in the U.N. 2030 Agenda for Sustainable Development (see below).[419]

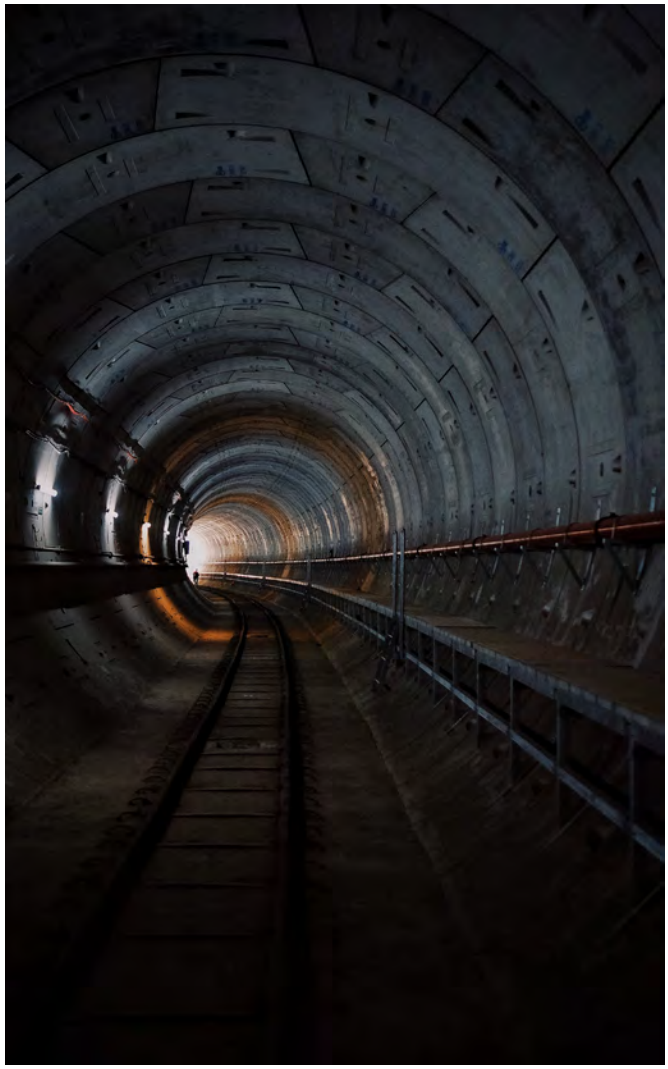
Over the past 25 years, the Global Environment Facility (GEF) has provided over $17 billion and leveraged $88 billion in support of over 4,000 sustainable development projects in 170 countries.[420] The GEF is the principal

intergovernmental financial mechanism to support many U.N. environmental conventions, including those on climate change, biodiversity, desertification, ozone, forests, and organic pollutants. But at only about $600 million a year, GEF provides less than 0.1% of what is needed to adequately address the scale of environmental decline. We need to admit that this is too little, and that we have to do better.

Governments must (1) Forgive debt of developing countries; (2) End perverse subsidies; (3) Tax unsustainable activities; (4) Apply additional revenues to sustainability; and (5) Regulate and enforce environmental protection.

Environmental Regulation/ Enforcement - In addition to tax and subsidy fiscal instruments, governments must exercise their authority to *regulate* environmental aspects of corporate behavior. In many cases, it is not enough to simply tax damaging corporate behavior and subsidize responsible behavior, as these measures may not work quickly enough. For instance, carbon emissions can indeed be reduced through tax and subsidy instruments, but likely not fast enough. In such cases, governments must go further and prohibit unsustainable behavior and/or require sustainable behavior. In addition, governments must *enforce* all environmental laws and regulations.

Green New Deal – A step in the right direction in the U.S. was the 2019 introduction into Congress of a resolution known as the "Green New Deal," underscoring the urgent need to address climate change, create green jobs, invest in green infrastructure (transport and buildings), and secure environmental justice. This focuses the conversation on the scope of the climate challenge. But the legislation remains aspirational; it is a general statement of broad goals, ignores other interrelated drivers of environmental decline (population, habitat loss, resource depletion, agriculture, water, contaminants, and conflict), and it is a non-binding resolution (would not legally require any policy change). If nothing else, the Green New Deal highlights just how far U.S. politics remains from where it needs to be in order to effectively solve the many synergistic elements of environmental decline at the scale and pace needed.



Industry

A dead planet is bad for business.

DAVID BROWER, ENVIRONMENTALIST, CIRCA 2005[421]

While government is the key to fixing this problem, it is also time for the private sector to rise to this challenge - in deed, not just in word. As 51 of the 100 largest economies in the world are corporations, the private sector clearly possesses substantial financial capacity to contribute to the central challenge of environmental sustainability in the 21st century.[422] We urgently need companies to intensify efforts to reduce their own ecological footprint, increase legitimate corporate social responsibility (CSR) initiatives, and improve energy and material efficiency. But we need more. We need more of their money invested in environmental sustainability initiatives, and we need it now.

The world's largest 500 companies include petroleum, automotive, electronics, mining, communications, airlines, banks, insurance, pharmaceuticals, food, merchandise, chemical, health care, defense contractors, power, clothing, entertainment, paper, heavy equipment, soft drinks, office equipment and other business sectors. In 2016, these top 500 companies together earned over $1.5 trillion in profits on $28 trillion in revenues – over a third of world GDP.

Some familiar names on *Fortune Magazine's* "Global 500" list include those as diverse as Wal-Mart, Shell, Toyota, General Electric, BP, Volkswagen, Bank of America, Exxon Mobil, Apple, Coca Cola, General Motors, Delta Airlines, AT&T, Ford, Honda, Chevron, Unilever, Dow Chemical, Home Depot, Nestle, Citigroup, Sony, Rio Tinto, FedEx, Proctor & Gamble, Google, Nike, Alcoa, Philip Morris, Boeing, and Archer Daniels Midland.[423] Together, the top 500 global companies possess an enormous, and as yet unrealized, capacity to help finance our transition to sustainability.

It is clearly in the interest of these companies, as well as the future of humanity, to invest in the sustainability of the biosphere. Again, "a dead planet is bad for business."

One laudable corporate effort is that of Phillips' (a Fortune 500 company) 2016-2020 "Healthy people, healthy planet" initiative, creating value through sustainable operations and sustainable supply chain solutions.[424] Phillips embeds sustainability and EcoDesign principles in all of its products, focusing on energy, packaging, materials, lifetime, and circularity (in which raw materials are recycled, not wasted). The company seeks to achieve carbon neutrality for its global operations by 2020 with energy efficiency, procuring electricity from renewable sources, and offsetting emissions via carbon credit purchases. This effort provides a model for other large companies, but as discussed below, these companies need to also make significant annual financial contributions to sustainability.

At its 2008 World Conservation Congress in Barcelona, the International Union for the Conservation of

Nature (IUCN) called upon the Global 500 companies to contribute at least 1% of annual profits to environmental conservation and sustainability – calling for establishment of the "1% Earth Profits Fund."[425] Unfortunately, the answer from the major companies was a resounding: "not interested."

Regardless, there are many ways companies can and should help meet this challenge. For instance, companies can voluntarily contribute into the "1% Earth Profits Fund," as proposed in 2008 by IUCN; or contributions could be made to the special Public-Private Partnership "Earth Fund" at the UNEP/World Bank Global Environment Facility (GEF); or a company might wish to donate 1% of revenues or profits directly to conservation initiatives of its own choosing. The latter is the model used by "1% For The Planet" in the U.S., where some 700 smaller companies donate 1% of annual revenues to conservation programs.[426] While laudable, "1% For The Planet" companies collectively donate a total of only $15 million per year, and the GEF "Earth Fund" has had a one-time contribution of only $50 million. This level is clearly not enough, as we need several orders of magnitude more than this to make a measurable difference. We must admit that the current level of investment in sustainability is insufficient.

The world's 500 largest companies - the "Global 500" - need to join this 21st century challenge by increasing investment in environmental sustainability. If all Global 500 companies would contribute 1% of annual *profits* to environmental initiatives, that would add another $15 billion per year. If they all contribute 1% of their annual *revenues*, that would add $270 billion per year. If these companies remain unwilling to make this level of investment voluntarily, government must collect it from them in taxes.

This is the level of increased investment that is needed to begin making a real difference in such urgent needs as biodiversity protection; sustainable agriculture, fisheries, and forests; sustainable energy and climate stability; water conservation; sustainable communities and economies; clean air; protected areas management; and population stabilization. And such an investment would enhance a company's reputation, market position, and ultimately, shareholder and company value.

Companies can either make this investment now, or the biosphere will continue to unravel, and we'll consign future generations to a world of unimaginable chaos, conflict, and deprivation - again, not a good business climate. Environmental sustainability would be the smartest long-term investment big business ever made. History will reflect kindly on those companies that rise to this challenge, and harshly on those that don't.

Finally, companies must authentically embrace "ecolabelling" regimes that establish environmental and social product standards, such as the Forest Stewardship Council for wood products; the Marine Stewardship Council for seafood; the Conservation Agriculture Network for farm products; Green Star Energy programs; and others.[427] All of these certification regimes should continually review, strengthen, and enforce their environmental standards.

Green Economy

To reach sustainability goals by 2030, we need a "4th Industrial Revolution" to a "Green Economy." This transition from a resource intensive/wasteful economy ("Brown Economy") must be achieved within the next 10 years for a "soft landing" transition. Given the International Labor Organization's (ILO's) estimate that more than 200 million youth globally are unemployed, there is considerable opportunity to bring this workforce into the green economy.

Green (as opposed to "brown") jobs are defined by the U.N. as:

> *Work in the agriculture, manufacturing, research and development, administrative, and services activities that contribute substantially to preserving or restoring environmental quality....this includes jobs that help protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency strategies; decarbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution.*
>
> U.N. Environment Program, 2008[428]

In 2008, UNEP, the ILO, and other partners formed the "Green Jobs Initiative" to enhance a just and equitable transition to green jobs. As discussed by the Green Jobs Network, green jobs include those in climate mitigation, habitat conservation, energy efficiency, sustainable agriculture, construction, architecture, recycling, renewable energy, water, environmentally smart technologies, wildlife protection, and wilderness management.[429]

Millions of "green collar" jobs can be derived from a green economy, providing a triple dividend of youth employment, climate mitigation, and achieving the U.N. Sustainable Development Goals.

The ILO estimates that perhaps 24 million "green collar" jobs can be derived from a green, zero-waste economy, providing a triple dividend of youth employment, Paris climate agreement compliance, and achieving the U.N. 2030 Sustainable Development Goals. But while 24 million jobs would be created, the ILO estimates that 6 million jobs would be lost from "brown collar" sectors such as fossil fuels, landfilling, mining, and other "smokestack" industries. Although there would still be a net gain of 18 million new jobs provided by the green economy, the 6 million lost brown collar jobs pose a significant political hurdle to overcome. A just transition from a brown to green economy is essential, with training and assistance with job placement for those who lose jobs. And government polices (as discussed above) will need to encourage the green economy transition with subsidies, taxes, and regulation.

Citizens the world over are pushing for the strengthening of democratic governance.

Restoring Democracy

Nowhere in the world is democracy functioning as it should. Nowhere. The wealthy and powerful in all societies continue to enhance and maintain their wealth and power through the political process. This is a well-documented phenomenon that disadvantages the majority of civil society and the environment. It is critical that citizens the world over push for continual strengthening of democratic governance.

This should include campaign finance reform, prohibiting undisclosed ("dark") money in campaigns (e.g., legislative repeal of the 2010 "Citizens' United" U.S. Supreme Court ruling that protects unlimited corporate contributions to political campaigns as "free speech"), providing public financing of campaigns, the elimination of politically biased "gerrymandering" of election districts, ensuring transparency in government, strengthening controls on corporate lobbying, controlling "fake news" and disinformation in campaigns, and the elimination of voter suppression. A good start in the U.S. was the 2019 introduction into the U.S. House of Representatives of H.R.1, the Democracy Reform bill that would:

- Create a national system for automatic voter registration and expand early voting and same-day registration;
- Make Election Day a holiday for federal employees and encourages private businesses to also take the day off to encourage voting;
- Require "dark money" groups to make their donor lists public and mandates that Facebook and Twitter

disclose the source of funding for political ads that appear on their platforms;
- Institute public financing for political campaigns;
- Enhance ethics rules to fight corruption in government.[430]

Despite decades of dedicated effort by thousands of NGOs, governments continue to marginalize environmental sustainability as a political issue. Corporate interests that have profited through environmental degradation and deregulation continue to control government in order to protect their wealth and power. Clearly, what we are doing isn't enough. Polite passivity and timidity enable business-as-usual, and it is time for greater resolve and boldness in making government work for the sustainability transition.

We the people have to make the environment a central issue at all levels of governance - local, regional, national, and international. Politicians need to understand that it's not just the economy that matters, but also environmental sustainability, and the two are inextricably linked. Citizens need to nominate and elect candidates who support progressive environmental policies, and need to express concerns on environment to all elected officials, proposing not just general views but specific, science-based legislative and administrative actions. Elected officials must be continually reminded that there is always enough money to do those things we consider important, and the environment is important. And to get big, dark money out of politics, we need public financing of all campaigns. Some creative environmental groups, such as Greenpeace and Extinction Rebellion, are finding new and innovative ways to get this message across to governments, industry, and the public.

The unprecedented dismantling of U.S. environmental policy resulting from the 2016 U.S. presidential election underscores the vulnerability of environmental governance everywhere. While U.S. environmental policy can and will be restored in future administrations, precious time on our path to sustainability has been lost. We cannot afford another such political setback at this critical time.

The global epidemic of misinformation and propaganda needs to be confronted with resolve, facts and truth. Citizens need to think deliberately; act and vote based upon science, evidence-based, factual information; and hold politicians to such standards. Today, there is a dangerous, collective delusion developing in some corners of national politics, in which some simply dismiss facts that are incompatible with their worldview in favor of a more convenient delusion that confirms their chosen identity. In effect, many people want to be lied to, to be told a fairy tale that confirms their deeply held beliefs. This dynamic is what has propelled many despotic, authoritarian leaders into government office around the world.

However, the anti-environmental policies of the Trump (and other) administrations may be so egregious that the long-term environmental effect could actually be positive, as these extreme anti-environment policies are reawakening public attention to the urgency of the issue. And regardless of which political party has held office in the U.S., environmental decline has continued, albeit at different rates. Perhaps the 2016 U.S. election was so dramatic that it could lead to a much-needed resurrection in environmentalism. We can no longer afford ignorance-based, delusional, self-interest politics.

Citizens' Advisory Councils

Effective democratic governance depends upon informed public participation, and several international conventions and policy guidelines call for enhanced public participation in environmental management.[431] Yet, large-scale resource development projects generally receive insufficient oversight by, and engagement with, civil society. In the absence of effective supervision and public engagement, corporate and government vigilance can weaken, complacency increases, environmental and social standards decline, and risks increase. Such insufficient oversight, lower standards, and complacency can result in acute and catastrophic damage, such as oil spills, chemical explosions, mine disasters, overharvest and population collapse; long-term chronic environmental degradation, social tension, mistrust, litigation, and even violence between local people, industry, and government.

To correct this problem, civil society stakeholders need to be directly involved in the review and oversight of resource industry operations that potentially affect their lives and environment, including extractive industries such as oil, gas and mining; and renewable industries such as agriculture, forestry, and fisheries. Local citizens have much at stake, and much to offer, in the safe and responsible conduct of resource development in their regions. To be effectively engaged, citizen stakeholders need their own organization with sufficient funding, staff, authority, broad representation, and independence. Governments and Financial Institutions should require the establishment of Citizens' Advisory Councils (CACs), to provide non-binding, informed public advice, oversight, and engagement with resource development.

These citizen councils should be funded either from government resource revenues or directly by industry, and should provide advice on all aspects of resource development projects. Citizen councils should be comprised of all major stakeholder constituencies potentially affected by a resource industry: e.g., Indigenous Peoples, fishing, farming, conservation, tourism, women, youth, science, and local communities. Properly structured, these CACs will become the *eyes, ears, and the voice* for local citizens regarding large-scale resource development projects that may directly affect them. One successful model that has functioned effectively for over 30 years is the Prince William Sound Regional Citizens' Advisory Council in Alaska, that receives about $4 million per year from the oil industry to ensure the environmental safety of the Alaska oil pipeline terminal and tankers.[432] This model is now being considered around the world.

Citizens' councils provide an on-going, structured mechanism for greater communication, collaboration, and trust between citizens, government, and industry, and should reduce industry's environmental impact, risk, and footprint. Citizen councils do not substitute for effective governmental oversight, but complement and enhance such. The establishment of Citizens' Advisory Councils is fundamental to industry's "social license to operate," genuine corporate social responsibility, citizen empowerment, environmental justice, and government legitimacy. Most importantly, citizen councils will help to reduce the environmental risks and impacts of natural resource industries.[433]

Some countries, such as Bhutan, have abandoned Gross Domestic Product (GDP) as a way to measure social development.

Redefining Progress

Conventional economics fails to account for resource depletion, lost cultures, pollution, habitat damage, climate change, health impacts, economic inequality and social corrosion. In short, conventional economics doesn't measure what we value most - quality of life. Indeed, Gross Domestic Product (GDP) simply measures total spending, including negative expenditures on such things as crime, disease, resource depletion, defense, long-term environmental damage, and pollution. While GDP is the conventional measure governments use to assess economies, it is clearly not a measure of wellbeing. Similarly, the Dow Jones, NASDAQ, and S&P may measure financial transfers, but they do not measure the actual, productive economy.

Fortunately, there are better ways of measuring progress and sustainable economic wellbeing. One is the "Genuine Progress Indicator" (GPI), developed by the group "Redefining Progress."[434] The GPI itemizes negative expenditures/costs of environmental degradation, auto accidents, resource depletion, carbon emissions, pollution, crime, health costs, and lost leisure time, and deducts these from positive economic contributions such as personal consumption, capital investment, higher education,

housework and parenting, volunteerism, and so forth. The balance is the Genuine Progress Indicator. The GPI analysis shows that over half of the current U.S. economy is nonproductive and unsustainable, and that the productive economy has been stagnant since 1970.

Another useful measure of actual progress was developed by the tiny Himalayan nation of Bhutan. Decades ago, the government there rejected the conventional economic measure of GDP in favor of what they call the "Gross National Happiness."[435] The four fundamentals of Gross National Happiness are equity, culture, environment and governance - nothing about economic activity. Such indicators represent a new paradigm in socioeconomic thinking - holistic measures of real progress and wellbeing that include environment, social integrity, equity, health, and contentment.

This encouraging paradigm shift seems to be spreading. In 2019, New Zealand moved beyond simply measuring GDP and adopted a more inclusive "Wellbeing Budget."[436] The new approach presents a Living Standard Framework (LSF) as a set of indicators to guide policy. The twelve LSF domains are: civic engagement and governance, cultural identity, environment, health, housing, income and consumption, jobs and earnings, knowledge and skills, time use, safety and security, social connections, and subjective wellbeing.[437] In 2010, the U.K. Office of National Statistics established its "Measuring National Wellbeing Programme" combining personal and economic measures of wellbeing as part of its "Beyond GDP" initiative.[438]

All governments should expand economic policy beyond the conventional GDP paradigm to include genuine measures of progress and environmental sustainability.

Some are redefining progress using measures such as "Gross National Happiness."

Combatting Corruption

Corruption places the interests of the few over the interests of the many. In fact, much of the global economy is structured to support corrupt practices. Corruption accelerates environmental decline, as many environmentally damaging development projects that are not economic or in the long-term interest of the public are approved for corrupt purposes. Until this perverse phenomenon is brought under control, little progress can be made in our needed sustainable transition.

Most nations are aware of the corruption problem, and have established national institutions attempting to control corruption, including legislation and anti-corruption commissions.

The only legally binding universal anti-corruption instrument, the 2003 United Nations Convention Against Corruption (UNCAC), is a laudable first step against corruption globally, and entered into force in 2005 with 186 state parties.[439] The UNCAC focuses on cross-border corruption, and provides a framework for international cooperation on the issue, including law enforcement and judicial cooperation. Both national and intergovernmental efforts to combat corruption deserve enhanced focus and support. Citizens Advisory Councils (discussed previously) also provide a robust deterrence to corruption.

Multilateral Environmental Agreements (MEAs)

Today there are over 500 legally binding Multilateral (international) Environmental Agreements (MEAs); many are global and some regional.[440] These agreements and treaties address issues such as marine pollution, air pollution, wetlands, trans-boundary pollutants, desertification, climate change, trade in endangered species, biological diversity, high seas fish stocks, pesticides, persistent organic pollutants, environmental impact assessment, public disclosure, whaling, tropical forestry, migratory birds, high seas fisheries, seabed mining, ozone depletion, and indoor environments. Some of these treaties are models of international cooperation and success: the 1989 Montreal Protocol to reduce stratospheric ozone-depleting chemicals such as chloroflourocarbons (CFCs) and hydrochloroflourocarbons (HCFCs); the 2001 Stockholm Convention to reduce persistent organic pollutants (POPs), and (hopefully) the 2016 Kigali agreement to phase out climate damaging hydroflourocarbons (HFCs) in refrigeration.

But most other international environmental agreements have been far less effective, particularly those that require significant social or economic behavior changes. In reviewing the implementation of many of the international environmental agreements, UNEP found "little or no" progress for many, including climate change, fish stocks, desertification, and biodiversity; and further deterioration for others, such as coral reef protection.[441] This has to change.

One problem is that while governments sign these environmental agreements, they also sign agreements on

Some Multilateral Environmental Agreements are working well, but most are not effective at all, including those for climate change, oceans, forests, and biodiversity.

trade, investment, and development that contravene these environmental agreements. Some countries sign, but refuse to ratify, environmental conventions. And even after signing and ratifying these MEAs, many national governments simply ignore them when developing national legislation and policy. Most observers agree that with some 35 different U.N. organizations charged with environmental governance headquartered around the world with overlapping or even contradictory jurisdictions and mandates, the international environmental governance system remains chaotic and ineffective.

Thus, there is urgent need to better organize, finance, enforce, and strengthen the existing U.N. system for international environmental governance. The U.N. system should be subjected to continuous, independent oversight and auditing of its environment programs.

There is urgent need to better finance, enforce, and strengthen the existing U.N. system for international environmental governance.

Science

Science is one of the most exquisite intellectual human endeavors ever created. Yet at its core, science is simply methodical observation - no more, no less. Observation is not action. Certainly, observation (science) should inform action (policy), but we need to be clear that knowing and doing are two different things.

One of our most dangerous self-deceptions today is the belief that simply studying environmental decline will somehow solve the crisis.[442] It won't. Studying climate change will not keep one carbon atom out of the atmosphere, and studying deforestation will not keep one tree standing. We urgently need governments to *act* on the science we already have. Science has done its job, now policymakers must do theirs, and act on that science.

Science will continue to observe, document, and predict impacts of environmental decline, but we already know enough about these disastrous impacts to know that we need to take bold, urgent action to solve it, and we know exactly what steps to take. Yet many in government, industry, and even academia continue to invoke scientific uncertainty as a self-serving political strategy to protect the existing unsustainable status quo, insisting that more study is needed *before* we take difficult steps to solve the crisis. This is a fool's bargain.

Scientific uncertainty is repeatedly used as an excuse to delay political action, particularly when such action threatens powerful interest groups. Tobacco was a tragic example, fossil fuels/climate change another. And on the environmental crisis, this approach would be an existential, catastrophic mistake. We know we are losing the environment battle, and we are running out of time to fix it.

Science in lieu of action is unconscionable.

AL GORE, FORMER U.S. VICE PRESIDENT, 1992[443]

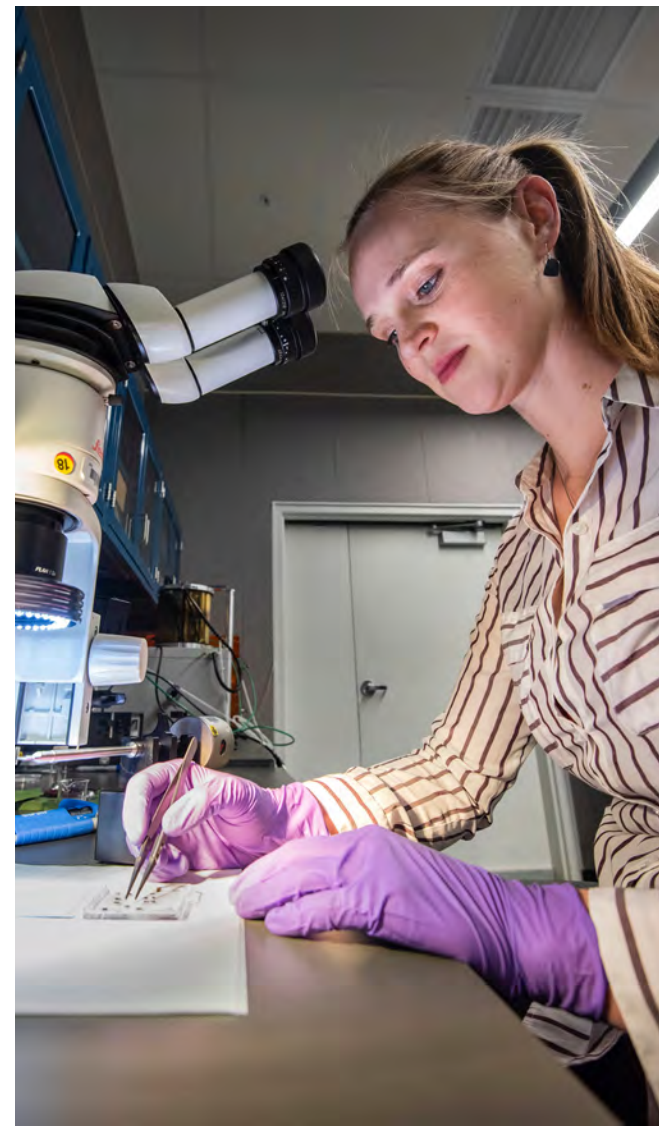
Without policy action derived from the growing body of environmental science, this knowledge does nothing to actually *avert* the crisis. All of this knowledge is useless if we do not choose to act on the information science has produced. While we continue to study climate change and biodiversity loss, carbon emissions continue to climb and species continue to be lost.

Future historians will undoubtedly reflect on the peculiar environmental politics of our time, where the causes, effects, and solutions to the crisis were well understood, but political paralysis and strategic disinformation delayed the solution. Scientists have a moral and professional responsibility to speak out about this existential crisis.

Another risk regarding the misuse of science by policymakers is what is known in systems theory as "sub-optimization," essentially using science to "do in the best possible way something that should never be done at all." For instance, regardless how much science and technology are applied in offshore oil and gas drilling in deepwater and Arctic environments, such projects remain high risk, unnecessary, and would delay our transition to sustainable energy. From a sustainability perspective, such projects should not be done at all.[444]

Perhaps the sciences most useful to our transition to sustainability will be political science, psychology, sociology, and psychiatry: understanding how public opinion is formed, the role of media, the role of science in public discourse, the distinction between propaganda and education, and the underlying bases of public opinion.

Science has done its job and done it well. Now it is time for policymakers to do theirs by applying the science and taking immediate action to solve the crisis.

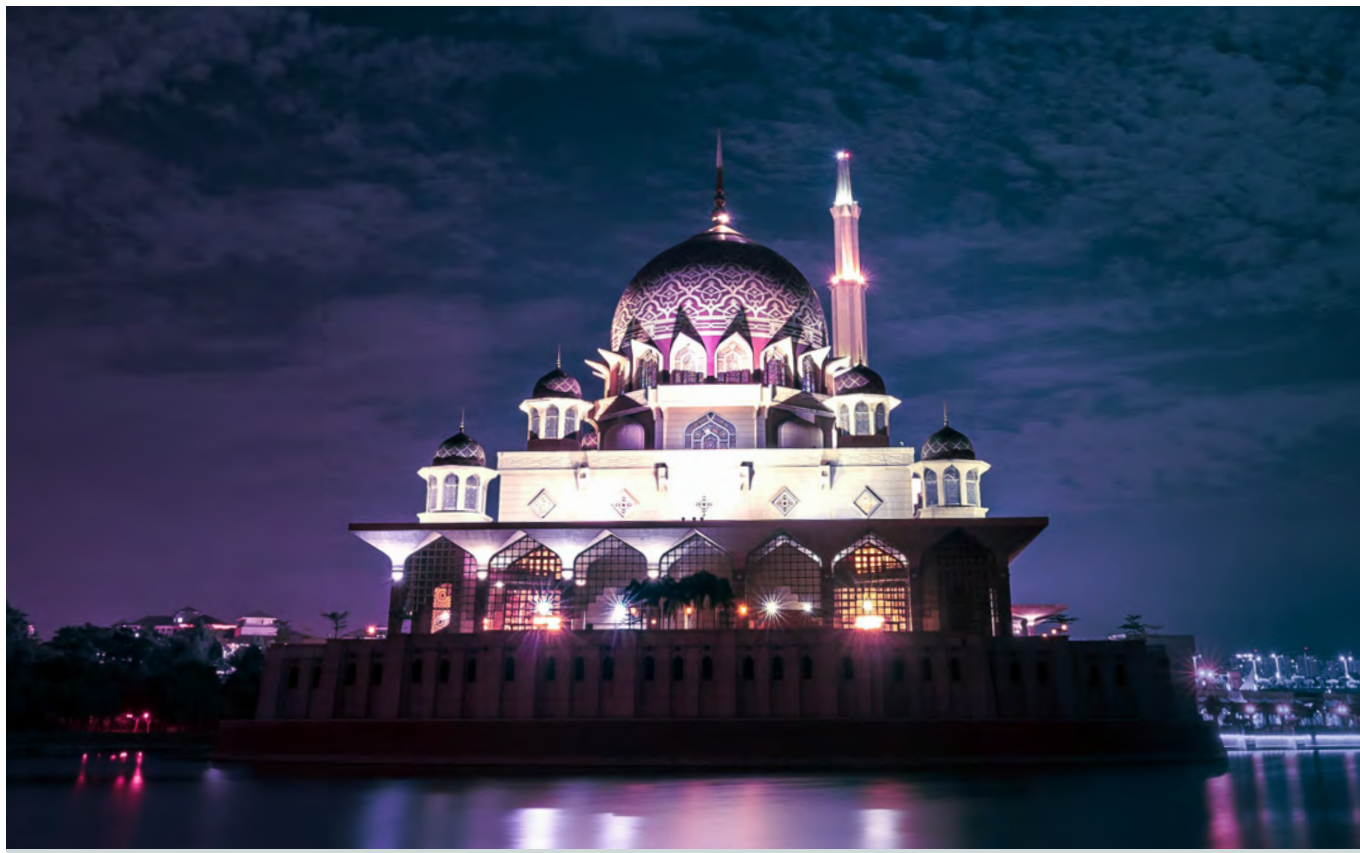


Religion

Although reversing ecological decline is primarily the responsibility of government, world religions must rise to the challenge as well. Over 5 billion people identify with one of the major religions, presenting a real opportunity to achieve positive environmental and social change. Many statements on environmental responsibility have been issued by world religions, including Christian, Islamic, Hindu, Buddhist, and Jewish.

The most comprehensive of these is the 2015 "Laudato si: On Care for Our Common Home" encyclical from Pope Francis, addressing many of the issues discussed above: pollution, waste, throwaway culture, climate change, resource depletion, freshwater, biodiversity, habitat loss, forests, oceans, poverty, inequality, corruption, and ineffective governance.[445] Similar environmental statements have been issued by all religions, but most stop short of calling for family planning, contraception, and population stabilization. Regardless, religious leaders should regularly commend these environmental statements to their followers, and encourage all to advocate such principles to government.

Even with these laudable environmental statements, most monotheistic religions believe that worshippers can be forgiven for sins on Earth and rewarded with eternal afterlife in a paradisiacal heaven above. Some invoke this thinking to excuse environmental destruction on Earth: if there is an afterlife in a promised land elsewhere, what happens here and now on Earth becomes less important. It would help if religions could reimagine the concept of "heaven" and "the promised land" to include the right here, right now on Earth. In essence, religion needs to make nature sacred again.



Most people identify with an organized religion today, and thus religions have enormous opportunity to advance environmental sustainability. Religions should again recognize nature as sacred.

The Arts

In contrast to technical deliberations of science and policy, the arts offer a powerful expression of deep human emotion. While science is of the head, art is of the heart, and visual arts, music, performance, and literature can connect with people in ways that science does not. Art can bypass the analytical mind and aim straight for memory and imagination, thus changing attitudes at the emotional, rather than the intellectual, level. In fact, research confirms that reading, especially fiction, increases empathy.[446] The arts can have a transformative effect on society and raise broad public awareness of issues such as extinction and environmental decline.

People protect what they love, and the arts help people love the natural world. Historically, nature writing catalyzed the conservation ethic in the U.S. The writings of Emerson and Thoreau, followed by Leopold, Muir, Carson, Abbey, Burroughs and others, created awareness, value and civic pride in our shared natural world. Major conservation legislation in the U.S., such as the 1964 Wilderness Act and the Endangered Species Act, had roots in art and literature.

Throughout history, every movement toward a more peaceful and humane world has begun with those who imagined the possibilities.

BARBARA KINGSOLVER, WRITER, 1999[447]

Art in its many forms is becoming increasingly effective in environmental activism around the world. For example, Hollywood films have contributed to public environmental concern: e.g., "The Day After Tomorrow," "Avatar," "The Milagro Beanfield War," "Erin Brockovich," "The Lorax," "Water World," "On Deadly Ground," "Happy Feet," and "Star Trek IV: The Voyage Home."

"Follow the Leaders" sculpture for U.N. Climate Conference, Berlin, 2011.

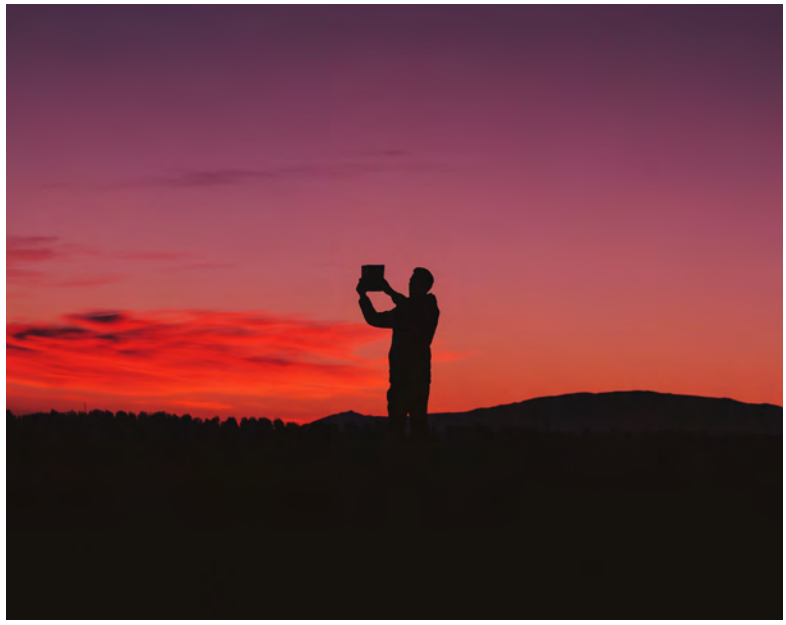
The arts are increasingly partnering with science and advocacy creating even greater impact. In 2018 the Union of Concerned Scientists' "Art-for-Science-Rising" project sponsored a collaboration between artists and scientists that produced provocative works of environmental art in public spaces around the U.S., including road signs and billboards with messages such as: *We are the Asteroid; Warning: Global Warming at Work; High CO^2; Triassic Weather Ahead;* and *Goodbye Arctic Ice.*[448] Greenpeace, too, has perfected the use of art in activism, and uses art creatively in most of its global environmental campaigns.

> *As we move closer to what surely will be unprecedented ecological, economic and social disruption, meaningful art can and must express the turmoil we encounter and help us process it intellectually and emotionally.... Everything will be up for negotiation, redesign and change. And artists will have the opportunity and duty to translate the resulting tumultuous human experience into words, images, and music that help people not just to understand these events mentally, but also to come to grips with them viscerally... Art can help us cope with the implications of our collective challenges. It can help prepare society for a possibly traumatic future. It can give voice to suffering and loss, helping people deal with life's inevitable stress. And it can also offer beauty, which can be especially important in hard times.*
>
> RICHARD HEINBERG, WRITER, 2018[449]

"Long-term parking."

Environmental Education

Educators around the world must expand environmental literacy in all components of society. Everyone, young and old, needs to be presented with the true, clear scientific facts of all aspects of our current global environmental crisis, including causes, consequences, and policy solutions in discussion. Environmental education should become a core requirement in all schools, beginning in primary school and continuing through middle school and high school. It should be a required course for high school graduation and a core requirement for all undergraduate degrees. Universities should expand environmental extension programs to put environmental science to work off campus, in society. In addition, students must be taught to better judge the veracity of the information they receive, from whatever source, and to distinguish fact from fiction and propaganda. Improved environmental literacy will help develop the informed political constituency necessary for environmental policy progress.



Rights of Nature

An encouraging development in recent years is the growth of the legal "Rights of Nature" movement. Central to the movement is that all ecosystems, living beings, rivers, oceans, and mountains have inherent legal rights, just as we humans have conferred upon ourselves.

> *Rather than treating nature as property under the law, rights of nature acknowledges that nature in all its life forms has the right to exist, persist, maintain and regenerate its vital cycles. And we – the people – have the legal authority and responsibility to enforce these rights on behalf of ecosystems. The ecosystem itself can be named as a defendant.*
>
> GLOBAL ALLIANCE FOR THE RIGHTS OF NATURE, 2017[450]

Ecuador was the first country to incorporate rights of nature into its constitution, in 2007, that it ratified by popular referendum in 2008. Subsequently, Bolivia has pushed the adoption of the Universal Declaration of the Rights of Mother Earth within the U.N., as well as passing its own Law of Mother Earth.[451]

In 2017, four rivers were granted legal "personhood" status, including the Whanganuri River in New Zealand, the Atrato in Colombia, and the Ganges and Yamuna in India.[452] The personhood designation intends to confer upon these rivers the same legal rights as people. The Ojibwe Nation (Chippewa) in North America has formally recognized the right of wild rice, or "Manoomin," to exist, stating: "Manoomin, or wild rice, within all the Chippewa ceded territories, possesses inherent rights to exist, flourish, regenerate, and evolve,

as well as inherent rights to restoration, recovery, and preservation."[453]

Such efforts are coming forward in many other countries at present, including Colombia, Sweden, the European Union, India, Argentina, Mexico, Brazil, and in the U.S. The Rights of Nature are becoming recognized broadly within the U.N. community:

> *The law has seen the beginning of an evolution toward recognition of the inherent rights of Nature to exist, thrive, and evolve. This evolving legal approach acknowledges that the traditional environmental regulatory systems generally described herein regard nature as property to be used for human benefit, rather than a rights-bearing partner with which humanity has co-evolved. Rights of Nature is grounded in the recognition that humankind and Nature share a fundamental, non-anthropogenic relationship given our shared existence on this planet, and it creates guidance for actions that respect this relationship. Legal provisions recognizing the Rights of Nature, sometimes referred to as Earth jurisprudence, include constitutions, national statutes, and local laws. In addition, new policies, guidelines and resolutions are increasingly pointing to the need for a legal approach that recognizes the rights of the Earth to wellbeing.*
>
> U.N. RIGHTS OF NATURE LAW AND POLICY, HARMONY WITH NATURE, 2017[454]

This trend should be encouraged legally, politically, and culturally.

Ecocide Law

Finally, another innovative approach to transitioning to a sustainable world would be to hold those responsible for its destruction criminally liable under international law. The concept of "Ecocide," comparable to genocide, was first proposed in 1972 by the University of London. As environmental writer George Monbiot relates, while the early 1996 drafts of the Rome Statute of the U.N. International Law Commission (ILC) included the crime of Ecocide as one of the crimes against humanity, the proposal was dropped at the request of the U.K., France, and the Netherlands.[455] Ecocide was again proposed in 2010 as an amendment to the Rome Statute to the ILC by British attorney Polly Higgins. The proposed amendment defines ecocide as follows:

> *Ecocide is the extensive damage to, destruction of or loss of ecosystem(s) of a given territory, whether by human agency or by other causes, to such an extent that peaceful enjoyment by the inhabitants of that territory has been or will be severely diminished.*
>
> ERADICATING ECOCIDE, 2019[456]

Ten countries now recognize Ecocide as a crime, including Georgia, Armenia, Ukraine, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, and Vietnam. However, these countries are ranked by Transparency International as high for corruption and low for respect of the rule of law; thus, the actual implementation and enforcement of these statutes has been questionable, at best.

The 2010 ILC amendment proposes to make Ecocide the 5th International Crime Against Peace, in addition to genocide, crimes against humanity, war crimes, and the crime of aggression. As discussed by Eradicating Ecocide, there is presently no duty of care (fiduciary duty) to prevent, prohibit, and preempt human-caused Ecocide. Criminalizing Ecocide would create a standard duty of care to prevent such significant harm to the biosphere, such as habitat destruction, pollution, and other damaging industrial activities.

> *Whilst we have many international agreements – voluntary codes of conduct, UN resolutions, Treaties, Conventions, Protocols, etc., the harm escalates. Not one of these international agreements prohibits Ecocide. The power of the law of Ecocide is that it creates a legal duty of care that holds persons of 'superior responsibility' to account in a court of law (both criminal and civil).*
>
> ERADICATING ECOCIDE, 2019[457]

If one of the 122 State Parties to the International Law Commission formally proposes adoption of the Ecocide amendment, and 83 of the parties then ratify the amendment, it would become legally binding and enforceable by the International Criminal Court at The Hague.

Monbiot writes that this act would make anyone who causes serious damage to, or destruction of, the natural world and Earth systems, including chief executives and government ministers, "criminally liable for the harm they do to others, while creating a legal duty of care for life on Earth."[458] He states: "These crimes against humanity should not be matters for negotiation but for prosecution."[459] While this will clearly take a paradigm shift by governments, this is precisely what needs to happen.

ENVIRONMENTAL GOALS

Population

To secure a sustainable future for the biosphere and civilization, the current ecological footprint of *H. sapiens* (the total impact of our species on the biosphere) needs to decline by at least 50%. A principal means of doing so is to stabilize global population numbers and reach zero population growth (ZPG) as soon as possible. Logically, it will be easier to equitably sustain a population of 8 billion people rather than 11 billion people. While population stabilization remains a controversial subject in international conversation, we simply have to have the conversation.

To equitably stabilize and sustain human population, governments must:

- Fully fund and provide easy access to non-coercive family planning and reproductive health programs, including access to contraceptives, in developing countries;
- Provide universal access to primary education;
- Eradicate illiteracy;
- Guarantee full paid employment, especially for women;
- Help women voluntarily prevent unintended/unwanted pregnancies.[460]

Governments should avoid China's failed "One Child" policy, as it was coercive, led to negative social consequences, and didn't work. During its "One Child" policy, China's population increased from 1 billion to over 1.4 billion today.

Contraceptives.

With supportive, non-coercive methods (education, and access to family planning, contraception, and reproductive care), the population in many countries is now stable or declining, and the *rate* of growth in world population has slowed. In countries that have a high standard of living, economic opportunity for women, and accessible family planning, the population has stabilized. In most places where women have choice, they choose to have fewer babies and certainly want adequate access to health care to reduce infant mortality.[461]

Of 211 million pregnancies each year, 87 million are unplanned and 56 million of those end in abortion, most under unsafe conditions, every year killing 68,000 women. Millions of reproductive age women say they don't want more children, and they must be supported in this desire. Providing for the millions of women who want, but don't have access to, family planning and reproductive health services will eliminate millions of unwanted pregnancies, abortions, and infant mortalities each year.

There are those who propose that the extinction of *H. sapiens* should be a goal for environmental sustainability.[462] This suggestion by the Voluntary Human Extinction Movement is, of course, highly controversial.[463] But as discussed below (Anthropocene-Ecocene transition), the *involuntary* extinction of *H. sapiens* is a real possibility unless we urgently halt and reverse the synergistic drivers of ecological decline.

Resources

Governments must improve standards and requirements for sustainable production and consumption with which to dematerialize and decarbonize the economy, targeting a stable, circular, zero-waste economy. The focus here is "doing more and better with less."[464] This can be achieved by requiring and subsidizing efficiency in resource use in all sectors of the economy: energy, agriculture, transportation, mining, and manufacturing. Governments must put an end to the *linear* "take, make, and waste" economy, in which materials are extracted, used once or twice and discarded, thus requiring more extraction. Instead, governments need to incentivize a *circular* economy, where materials are used efficiently and remain in circulation for as long as possible. To accomplish this transition, governments must tax or prohibit waste, subsidize or require efficiency, or a mixture of these policy instruments. Economic focus needs to shift from growth to stability and equity.

Governments must require circular "cradle-to-cradle" component design and manufacture in cars, appliances, buildings, and electronics. Japan and Germany now require cars and appliances to be designed in components so they can be disassembled and reused/recycled. Apple recently announced a corporate goal for 100% closed-loop sourcing of all the material it uses in its electronics manufacture.[465] While Apple has yet to set a target date to achieve this goal, this is the high standard that all companies should set voluntarily, or that governments should require.

Developing an economy with "ultimate circularity" is much broader than simply "reduce, reuse, recycle"

familiar to many. As outlined in GEO 6, ultimate circularity involves the following:

- Recover – Energy recovery from incineration of materials;
- Recycle – Process materials to obtain the same or lower quality;
- Repurpose – Use part of discarded products in a new product with different function;
- Remanufacture – Use part of discarded products in a new product;
- Refurbish – Restore old products and bring them up-to-date;
- Repair – Repair and maintain defective products so they can be reused;
- Reuse – Reuse by another consumer of discarded but still functioning products;
- Reduce – Increase efficiency in manufacturing and use through ecodesign;
- Rethink – Make product use more intensive by sharing or developing multi-function products;
- Refuse – Stop making products with limited or dubious function (avoid useless products, buy locally in order to limit transport, don't produce products that are destined for the dump).

Some of the world's largest consumer goods companies – Procter & Gamble, Unilever, PepsiCo, and others recently announced the "Loop" initiative, to reduce single-use plastic waste by providing products in reusable packaging.[466] After use, consumers would place the empty containers in a Loop tote, to be picked up by a delivery service, returned to the manufacturer, cleaned and reused once again. We know how to do this, as by necessity, our grandparents did this all the time.

The Factor 10 Institute, an international body of governments, NGOs, industry, and academia, is pushing to achieve a 10-fold increase in the efficiency with which energy and materials are used, and doing so within one generation.[467] A positive example of reduction in municipal waste is Ljubljana, the capital of Slovenia, where over 68% of all "waste" is now recycled.[468]

Consumers can and must reduce their individual ecological footprint by making deliberate, environmentally sound consumer choices in transportation, food, housing, appliances, recreation, apparel, and in all purchasing choices. A growing body of green consumers will motivate green corporate decision-making in a competitive green market.

As previously discussed, companies and consumers must further embrace "ecolabelling" regimes that establish environmental and social product standards, such as the Forest Stewardship Council for wood products; the Marine Stewardship Council for seafood; the Conservation Agriculture Network for farm products; and Green Star Energy programs.[469]

International Financial Institutions such as the International Finance Corporation (IFC), the International Bank for Reconstruction and Development (IBRD), and the World Bank have established general environmental and social performance standards for all of their development loans.[470] These standards include assessment and management of environmental and social risks and impacts; labor and working conditions; resource efficiency and pollution prevention; community health, safety and security; land acquisition and voluntary resettlement; biodiversity conservation and sustainable management of living natural resources; Indigenous Peoples; and cultural heritage. And 91 financial institutions in 37 nations have now endorsed the "Equator Principles," which also reinforce similar environmental and social standards.[471] While these investment environmental performance standards are indeed laudable, there are significant questions regarding how rigorous they are actually implemented. Independent oversight, implementation, and enforcement of these investment environmental standards need continuous improvement.

Consumers must advocate for environmental policies and Corporate Social Responsibility (CSR) improvement at shareholders meetings and to corporate boards, and insist that companies adopt the principles of the Coalition for Environmentally Responsible Economies (CERES) that include protection of the biosphere, sustainable use of natural resources, reduction and disposal of waste, wise use of energy, risk reduction, safe products and services, damage compensation, disclosure, environmental directors and managers, and assessment and audit.[472] Consumers should closely monitor the authenticity of CSR efforts and beware of corporate attempts at "greenwashing." If industry fails to act responsibly, consumers should recommend that public funds be divested, and subject such companies to boycotts and negative media exposure. As well, individuals can direct personal investments into Environmental, Social, and Governance (ESG) screened holdings.

But again, and importantly, while voluntary consumer and corporate efforts are useful, alone they will be insufficient to reduce resource consumption/depletion to sustainable levels quickly enough. This is an unequivocal responsibility for government.

Biodiversity

> *To truly witness this moment on Earth, we can't just name the species lost. We must mourn them.*
>
> ALISON KEIMOWITZ, PROFESSOR, 2018[473]

Some ask why save biodiversity? While the question itself betrays a troubling Anthropocentric disconnect from the biosphere, the answer is worth restating clearly. Reasons to save biodiversity include:

- ***Ethics*** - All species have an inherent right to exist. As David Ehrenfeld writes: "Long-standing existence in nature is deemed to carry with it the unimpeachable right to continued existence."[474] Biologists Paul and Ann Erlich suggest that the ultimate form of arrogance is the human belief that we are the only important life form and that we alone should decide whether or not other species live. Other arguments for preservation of biodiversity include our fascination and enjoyment of living beings, compassion, aesthetics, morality, and intrinsic value of all life.
- ***Pharmaceuticals*** - Many pharmaceuticals are derived from plants, like aspirin and morphine. Chemicals from plants are principal ingredients in a quarter of all prescriptions written annually in the U.S.: antibiotics, sedatives, antidepressants, muscle relaxants, anti-malarial agents, HIV control, anaesthetics, analgesics, blood thinners, blood-clotting agents, cardiac stimulators, hormone inhibitors, anti-cancer drugs, contraceptives, and diuretics.[475] As less than 5% of flowering plants have even been tested for potential medicinal properties, there is enormous medicinal

potential in the plant world, particularly in the tropical rainforests of Amazonia and Borneo, and marine ecosystems.

- ***Food*** - All of our food sources are derived from biological organisms. Humans have used perhaps 3,000 species of plants for food, but only 150 or so to any commercial extent. The staple foods for humanity are three grasses: corn, rice, and wheat. Clearing of forests for monocultures is self-defeating, as many potentially valuable food species are extinguished. The future of agriculture depends on maintaining the genetic variability of plants in natural ecosystems, which is important in disease resistance and maintaining yields in crops.
- ***Ecological Services*** – Perhaps the most important reason to protect biodiversity is the indirect ecological services provided, for free. Natural ecosystems control atmospheric oxygen levels, CO^2 levels, methane, pollutants, and waste. And many potentially detrimental organisms are presently kept in check by natural ecological processes. As the Erlichs write: "It seems certain that organisms capable of competing seriously with man for food or of doing us harm by transmitting diseases are now controlled *gratis* by other species in natural ecosystems."[476] Upsetting these ecological services could have disastrous consequences to the human condition. Ecological services provided by biodiversity exceed $300 billion per year, but we spend less than $10 billion each year to protect and maintain them. And, biodiversity provides incalculable value to the mental health of humanity.

To slow species extinction and save biodiversity, we urgently need to protect ecological habitat, stabilize human population, reduce resource consumption/waste, stabilize climate, reduce/eliminate invasive species introduction, and end illegal hunting and trade in protected species.

Paramount in this effort is the protection of ecological habitat. Today less than 15% of the terrestrial and inland waters of Earth, 17% of marine areas within national jurisdiction, and 4% of the open ocean are in protected status.[477] Many of these protected areas are only "paper parks," with little enforcement, funding or protective management.[478] There are now some 160,000 protected areas on land, and some 6,500 marine protected areas. Biologist E. O. Wilson and colleagues propose that at least half of the biosphere be placed in protected status, calling this the "Half-Earth Project."[479] This may be challenging, but it is essential if we want a sustainable future. Venezuela, Bhutan, and New Caledonia have already protected over 50% of their land area.

Although the biodiversity/habitat conservation challenge before us is significant, strategic priorities have been identified. One analysis concluded that 44% of all plant species and 35% of all vertebrate species are now confined

to just 2.1 million km², or 1.4% of the land surface of Earth, having formerly occupied some 17.4 million km², or 11.8%.[480] These are called "biodiversity hotspots" – biologically rich areas with extraordinary concentrations of species, high endemism, and under the greatest threat of destruction.

The eight "hottest of the hotspots" include Madagascar, the Philippines, Sundaland (Malaysian Peninsula and Indonesia), Brazil's Atlantic Forest, the Caribbean, Indo-Burma, Western Ghats and Sri Lanka, and the Eastern Arc and Coastal Forests of Tanzania and Kenya.[481] All have less than 10% of their original vegetation-cover remaining. Clearly, these and other hotpots must receive priority consideration in a triage approach for biodiversity conservation. And substantial habitat areas surrounding these biodiversity hotspots should be protected and allowed to gradually recover to their natural ecological condition, in order to provide additional buffers from disturbance.

Beyond these biodiversity hotspots, other extensive habitat areas need immediate protection. One comprehensive analysis identified 238 representative and outstanding terrestrial (142), freshwater (53), and marine (43) ecoregions in need of protection – "The Global 200."[482] Selection criteria included species richness, endemism, higher taxonomic uniqueness, unusual ecological or evolutionary phenomena, and global rarity. The identified ecoregions include tropical forests, temperate forests, taiga, arctic tundra, grasslands and savannas, deserts, shrub lands, coastal rivers, large deltas, coral reefs, estuarine ecosystems, and polar and sub-polar marine ecosystems.

Examples of The Global 200 include Australia's Great Barrier Reef, the Florida Everglades, the Ganges Delta, the African Rift Lakes, the Yangtze River, South Africa's Fynbos shrub land, the Namib-Karoo Desert, the Maoke Range of New Guinea, the Zambezian savanna, the Chukotka tundra, coastal mangroves of Southeast Asia, boreal forests of Canada and Russia, dry tropical forests of Bolivia, and the Choco-Darien region of northwestern South America. Some of these areas have some existing protections, but most of these protections fall short of what is needed.

Another analysis of the world's primary forest cover found that 70% of the world's remaining "frontier forests" - large, intact, undisturbed natural forest ecosystems are

found in just three countries: Brazil, Russia, and Canada.[483] Further, although most countries have already lost all of their frontier forest, or are on the verge of doing so, several countries offer great opportunity to conserve remaining forest cover: Brazil, Venezuela, Russia, Colombia, Canada, Guyana, Suriname, and Guiana.

In the polar regions (above 60° N and S latitude), the single greatest threat to biodiversity is climate change. These high-latitude ecosystems are structured around the cryosphere – sea ice, glaciers, and permafrost. Warming is causing a dramatic loss of the entire cryosphere of the Arctic and Antarctic. Arctic ecosystems are also threatened by proposed resource development projects, including oil and gas extraction, mining, shipping, and commercial fishing.[484] A legally binding Arctic Treaty should be negotiated at the U.N., in which all waters beyond 12 miles from shore are protected in an International Arctic Marine Sanctuary. As well, Antarctic marine protections should be significantly enhanced, including a significant restriction of krill fisheries, and establishment of additional protected marine reserves.

In addition to habitat conservation, to protect plant biodiversity, the seed collections at the Svalbard Global Seed Vault in Norway, and Kew Botanical Gardens (Millennium Seed Bank) in London must be expanded, fully funded, and maintained. As well, there is an urgent need for governments to enforce agreements to eliminate poaching and illegal trade in endangered species and other wildlife. There is considerable opportunity to reduce the illicit wildlife trade and population declines by exposing common misrepresentations regarding medicinal and therapeutic values of various wildlife parts in Traditional Chinese Medicine (TCM).[485]

The key to saving biodiversity is to commit sufficient financing to the effort. Such funding is a key component of the additional $2 trillion per year proposed here for the Living Planet Emergency Fund to transition to sustainability. That there is substantial overlap in identified habitat/biodiversity conservation priorities should give policymakers confidence in directing funds to them. Decisions as to where to allocate monies would probably best be decentralized into the various regions and the habitat-rich nations themselves. And it is imperative that sufficient monies be allocated for local communities to participate in the management and enforcement of protected areas (from illegal logging, poaching, mining, and grazing), and for the development of sustainable economic alternatives to habitat destruction.

Forests

World governments urgently need to halt deforestation. This can be achieved using tax, subsidy, and regulatory authorities. Forest conservation objectives must be to:

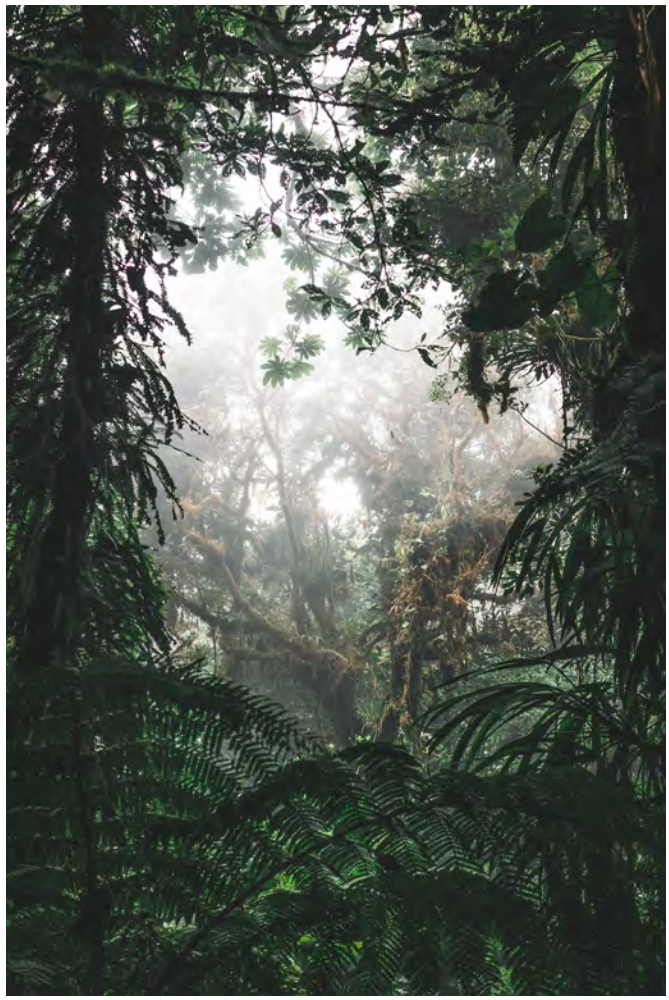
- Protect all remaining old-growth, frontier forests (less than 10% are fully protected now);
- Replant and restore deforested areas;
- Establish protective buffers around all protected forests;
- Require sustainable forestry in all managed (harvested) forests (Forest Stewardship Council certification);
- Carefully manage intensive plantation production;
- Reduce timber demand by recycling and using product alternatives.

Governments must set a global goal of zero deforestation and the restoration of original forests. To accomplish this, governments must tax/prohibit deforestation, and subsidize/require forest conservation, restoration, and reduced demand for timber. There are countless examples that demonstrate this is possible.

In 1998 the World Bank and the World Wildlife Fund (WWF) formed the Alliance for Forest Conservation and Sustainable Use, helping to protect 100 million acres of forest, and set a global goal of zero deforestation by 2020.[486] That goal will not be reached, but it is the correct goal to set. The Forest Stewardship Council has now certified over 130 million acres of forest in 65 countries.[487] Korea has already reforested much of the forest land lost in the Korean War.

China, which has lost over 98% of its original forest cover, is planting a "Great Green Wall" (also called the "Three North Shelterbelt Project"), envisioned as a strip of trees over 2,800 miles long to protect lands from the encroaching Gobi Desert, to be completed by 2050.[488] But initially, the government planted non-native trees that drew more water from the deep aquifer and caused more environmental damage. Many of the trees planted have died. Similarly, the African Union initiated a $4 billion "Great Green Wall of the Sahara and Sahel" project, a wall of trees stretching thousands of miles to stop the encroaching Sahara and combat climate change.[489] About 15% of the African green wall has been planted, and the aim is to plant 100 million acres of forest, providing food security for over 20 million people, 350,000 jobs, and ultimately sequester over 200 million tons of carbon. And on just one day in July 2019, Ethiopia planted over 350 million trees as part of its "Green Legacy" reforestation campaign and plans to plant a total of 4 billion trees during the 2019 rainy season.[490]

In much of the developed world, more than half of all paper used is now recycled. In the developing world, use of fuel wood needs to be reduced by using more efficient wood stoves and replacing them altogether with solar thermal cookers and/or electric hotplates powered by wind and solar power. All such efforts deserve government support.



Food and Agriculture

Increasing food production can only keep up with growing demand and rising population to a point. The most important way to ensure food security for the world is to stabilize food demand by stabilizing human population.

Beyond this, the overall challenge is to increase food productivity while decreasing the environmental impact and footprint of agriculture. To do so, governments must eliminate subsidies to unsustainable agriculture, and transfer these subsidies to sustainable practices that employ an ecosystem approach. Sustainable agricultural (e.g., conservation agriculture and regenerative agriculture) practices include recycling crop waste and manure, drip irrigation to conserve water, soil conservation, organic farming, planting drought-tolerant crops, growing legumes to fix nitrogen in soil, crop rotation, terracing, no-till farming, wind breaks to reduce erosion, energy efficiency, renewable energy use, and "smart farms."[491] Smart Farms integrate advanced technologies, including autonomous robots, driverless tractors, drones for sensing and aerial planting, intelligent automatic watering, automatic harvesting, remote sensors and the Internet of Things (IoT) to reduce water and fertilizer use, and improve yields and efficiencies.[492] These technologies reduce the ecological footprint of agriculture, and represent the future of farming.

Historically, increases in grain production derived from a corresponding increase in irrigation (often from fossil aquifers), energy use, and pesticide and fertilizer use. Such environmental costs are unsustainable, as fossil aquifers continue to drop, grazing pressures increase, biofuels compete for land, soils erode, forests are cleared, fuel costs rise, biodiversity declines, and fertilizers become scarce.

Shifting to food production and consumption lower on the food chain will increase productivity as the efficiency of protein conversion increases lower on the food chain. Again, studies have shown that an area of land that can produce 4 grams of protein from beef can produce 100 grams of edible protein from plants.[493]

By far the best option for sustainability would be to stop producing and consuming meat and dairy altogether. A 2014 study estimated that there were 375 million vegetarians and vegans worldwide, only about 5% of world population.[494] Environmentally, increasing vegetarian/vegan diets will significantly reduce greenhouse gas emissions, habitat loss, land degradation, and freshwater use. As well, vegetarianism/veganism has the ethical benefit of avoiding the abusive conditions of crowded industrial feedlots.

> *A vegan diet is probably the single biggest way to reduce your impact on planet Earth, not just greenhouse gases, but global acidification, eutrophication, land use and water use.*
>
> JOSEPH POORE, ENVIRONMENTAL SCIENTIST, 2018[495]

At a minimum, meat production and consumption must be cut at least in half, as quickly as possible. Reducing meat production and consumption should become a central sustainability goal and incentivized by government. One way governments can help with this is to impose significant sales taxes on meat, such as the 19% tax (to increase from the current 7%) on meat proposed in 2019 by members of the German parliament to combat climate change and improve animal welfare.[496]

Recent developments in meat substitutes offer exciting opportunities to provide food while reducing livestock impacts to the biosphere. These technologies include "cellular agriculture," in which "cultured meat" is grown from animal cells in the laboratory, as well as "molecular" wines and whiskeys. Many meat substitutes

are now being made from many plant-based sources, and are rapidly increasing in popularity. In addition, there are now many alternatives to dairy including: milk from rice, soy, almonds, cashews, hemp and flax; using coconut oil or avocado oil instead of butter; and vegan cheese from cashews.[497] Some fast food chains, such as *Kentucky Fried Chicken*, are now testing plant-based meat substitutes, and new plant-based food companies such as *Beyond Meat* are thriving.[498] Substitutes to meat and dairy offer considerable reductions in carbon emissions, reduced land clearing for livestock ranging, and avoidance of cruel animal husbandry practices such as feedlot and cage production.

There is an urgent need to reduce the number (now over 4 billion) of grazing livestock throughout the world - sheep, goats, cattle, and buffalo. Ranging livestock cause excessive damage to grassland ecosystems by compacting soils and overgrazing, forest loss, soil erosion, and greenhouse gas emissions.[499] Here, the major concern is large-scale industrial livestock operations, not small-scale family herding. Thus, large-scale industrial production of animals must be significantly curtailed.

Governments must stop subsidizing overgrazing, land clearing, and the degradation of farmlands, and increase subsidies to environmentally sustainable alternatives. The U.S. soil conservation program initiated after the infamous 1930s "Dust Bowl" is a successful model.[500] The program established wind breaks with trees around fields (to reduce wind-blown erosion), crop rotation to allow soil fertility and moisture to recover, and retired millions of acres from production and into permanent grass and tree cover. Also, farmers were encouraged to employ conservation tillage (reducing runoff of excess fertilizers), terracing, no-till, and minimal tilling to improve resistance to wind and water erosion. These efforts

reduced soil erosion on U.S. farmlands by some 50%, saving billions of tons of topsoil. Such measures are now being replicated across the world, and should be incentivized by governments.

Additionally, growing several crops seasonally on the same land (wheat and corn, wheat and rice, winter wheat and summer soy), or "multi-cropping," can significantly increase food productivity. Fertilizer is still needed in Africa, Asia, and Latin America, but remains difficult to distribute, and alternatives such as planting leguminous trees with grain crops and use of manure instead of synthetic fertilizer will certainly help.

Governments must severely restrict or prohibit use of chemical pesticides on industrial croplands, subsidize safer organic alternatives, and subsidize or require a shift to controlled-release fertilizers that reduce waste and are more durable in soils.

Finally, governments and the agricultural industry need to enhance efforts to reduce food waste, which today accounts for 25% to 30% of the total amount of food produced annually. This can be accomplished with improved harvesting techniques and better timing, on-farm storage, infrastructure, transportation, packaging, retail, and education.[501]

Freshwater

To conserve the world's precious freshwater supplies, governments must reduce water waste; increase efficiency of irrigation and industrial use; retain more freshwater for river ecosystem functions and to support downstream floodplains, deltas, and wetlands; and satisfy the basic water needs of people for drinking, cooking, and sanitation.[502]

As irrigation uses over 70% of all the freshwater used by humans, and much of this is lost to evaporation and runoff, there is an obvious need to improve the efficiency of irrigation. Governments must increase the price of water with taxation and eliminate water use subsidies that encourage waste. Irrigation efficiency can be as low as 25% to 40% in countries such as India, Pakistan, and Mexico, and only 50% in much of the rest of the world.[503] Just switching from flood irrigation to drip irrigation can prevent half of all irrigation water loss. In dry areas, there is a need to shift to more water-efficient crops: wheat is less water-intensive than rice. And food production and consumption lower on the food chain requires significantly less water use than beef production.

There is also the need for greater industrial and household water-use efficiency, with low-flow toilets and showerheads, as well as increased water recycling. Israel now recycles 86% of all the water that goes down the drain and uses it for irrigation.[504] Large dams that are no longer necessary should be removed, as some have been in the U.S. All such water efficiency measures can and should be subsidized and/or required by governments.

Desalination is increasingly used to produce freshwater from seawater in arid climates, mostly with reverse osmosis membrane technology. Today more than 300 million people get their freshwater from over 17,000 desalination plants in 150 countries.[505] However, desalination is energetically costly, marine organisms are entrained and killed in seawater intakes, and brine discharge can affect coastal ecosystems. As desalination plants increasingly use renewable energy technologies such as wind and solar, energy costs and impacts will decline. New, more efficient desalination technologies deserve research, including more effective membranes and osmosis technologies.

Proposals to build freshwater pipelines (such as from rainy Southeast Alaska to dry southern California), shipping water in tankers, or towing large icebergs from the Antarctic to arid regions, while perhaps technically feasible, may be a long way from being cost-effective. One company in the arid United Arab Emirates (UAE), where groundwater is expected to run dry within 15 years, recently proposed towing Antarctic icebergs to the country, estimating that an iceberg with 20 billion gallons

would meet the water needs of a million people for five years.[506] However, the iceberg would need to be towed for a year, across 10,000 km of open ocean, while melting and breaking up in route, presenting significant technical and economic challenges. There are so many technical hurdles with this idea that more feasible alternatives should receive higher priority. As with food, the most important part of the sustainable water equation is to reduce demand and more efficiently manage the available resource.

The United Arab Emirates is proposing to tow Antarctic icebergs (such as this) to the country as a freshwater source.

Energy and Climate

Given the amount of CO^2 already in the global atmosphere, the resulting committed warming, the current and likely future emissions trajectories, and the political paralysis surrounding the energy/climate crisis, it seems a virtual certainty we will exceed the +1.5°C threshold, and likely even the +2°C threshold. This is an ominous reality. Regardless, it is imperative that we do everything possible to reduce emissions and warming as much as possible. Every ton of carbon we keep out of the atmosphere and ocean now, will help mitigate the severity of climate chaos in the future.

Thus, we must maintain and work toward the goal of stabilizing atmospheric temperatures at less than +1.5°C above historic baseline (global temperature has already increased 1°C); reducing atmospheric CO^2 levels back to 350 ppm (now over 415 ppm and rising); and reducing global anthropogenic greenhouse gas emissions 80% by 2050, from the current 40 billion tons (CO^2 equivalent) a year to less than 10 billion tons a year. To achieve this, we need far more than the existing Paris commitments from governments. As the U.N. Secretary General's climate envoy Louis Alfonso de Alba stated recently, to do so will require "an exponential increase in ambition" by world governments.[507]

The U.N. Intergovernmental Panel on Climate Change (IPCC) outlines the stark difference in effects between a +1.5°C and a +2°C warming, concluding that limiting warming to the +1.5°C target would require cutting global greenhouse gas emissions 50% below 2010 levels by 2030, and to achieve net zero global carbon emissions by 2050.[508] This will require transformative change in our energy economies.

The science varies regarding how much more carbon can be emitted while keeping warming below +1.5°C or +2°C. The IPCC 5th Assessment Report (2014) concludes that, to have a 50% chance of remaining under +2°C, cumulative future global emissions must be held to roughly 1 trillion tons of CO^2; and to keep below +1.5°C, future emissions must be held to 400 billion tons of CO^2. The more recent (2018) IPCC report estimates future emissions limits of 1.5 trillion tons of CO^2 will be required to stay below the +2°C threshold; and 760 billion tons of CO^2 to meet the +1.5°C scenario. At today's emissions rate, the 760 billion ton threshold would be exceeded in less than 20 years. However, global greenhouse gases contained in proven fossil fuel reserves today amount to more than 3 trillion tons.[509]

While the +1°C warming today is expected to persist for centuries or even millennia, the IPCC concludes that it is still possible to limit warming to +1.5°C, and it is critical to do so.[510] Again, given the committed warming and CO^2 already in the atmosphere, this seems unlikely, but the goal should remain. To reach this target would take a *revolutionary* effort, requiring exceptional transition in our energy, transportation, land use, agriculture, and industrial systems. The technologies exist to accomplish this, but they need to be deployed at a massive, unprecedented scale and pace. Keeping to the +1.5°C target will also require removal of CO^2 from the atmosphere through direct air capture, reforestation, and marine permaculture.

Fortunately, public opinion seeking urgent action is now growing, likely due to catastrophic wildfires, hurricanes, floods, and droughts in recent years. Recent polls show that, despite well orchestrated disinformation campaigns by fossil fuel interests, most people now accept the science that climate change is caused mostly by anthropogenic activities, and almost half support a carbon tax to reduce emissions.[511]

The benefit/cost of investing in climate mitigation is clear and convincing. The human health benefits alone of reducing global carbon emissions to hold to the +2°C limit are twice the cost of not doing so - $54 trillion in

International Thermonuclear Experimental Reactor (ITER), a full-scale nuclear fusion reactor in construction in France

health benefit vs. a cost of $22 trillion.[512] When one adds the ecological, agricultural, and other ecosystem services benefits of this mitigation effort, the benefit/cost ratio would be even more favorable.

To remain below the +1.5°C target, we need to de-carbonize the energy economy with an aggressive initiative in energy efficiency, a substantial increase in low/no carbon energy alternatives, eliminate deforestation, expand reforestation, reduce livestock agriculture, and enhance carbon capture/sequestration. These must all occur simultaneously. The only path to energy/climate sustainability (the +1.5°C scenario) is to leave most of the identified hydrocarbon reserves right where they are now – in the ground and seabed.

Two broad, immediate goals are to: 1. Substantially increase energy efficiency, and 2. Substantially increase low/no carbon alternative energy sources.

We urgently need a five-fold increase in energy efficiency (a five-fold reduction in energy intensity) in all sectors of the economy: automobiles, subsidize hybrid-electric vehicles, light-weight high-efficiency vehicles; airline efficiency; mass transit systems in urban and rural areas; power utility efficiency; commercial and residential building energy efficiency; home appliance and lighting efficiency; and manufacturing process efficiency. Energy efficiency is the easiest, most cost-effective way to reduce carbon emissions and is expanding rapidly around the world. The economies of Western Europe and Japan are roughly twice as energy efficient as the U.S. economy today. All governments should enact similar energy efficiency policies.

A rapid electrification of global transportation is necessary to achieve the required emissions reductions to meet a +1.5°C scenario. This will require significant increases in battery-powered passenger cars, commercial trucks, buses, and trains, and a phase-out of the internal combustion engine. As well, even commercial aircraft can switch to electric power. A small all-electric aircraft made by Eviation is now the first in commercial passenger service.[513] Several of the nine electric passenger planes, made from lightweight composite materials, with a range of 650 miles on 900 kilowatt hour lithium ion batteries, were purchased in 2019 by Cape Air, a regional carrier in the eastern U.S.[514]

Governments must incentivize and pay for the transition to low/no carbon energy alternatives, such as wind, solar, geothermal, wave, and nuclear fusion. Wind and solar energy are the fastest growing energy sources in the world today, and they need to be further incentivized

with government subsidies. The world's largest solar plant is in construction in Port Augusta, Australia, and is expected to provide 100% of South Australia's energy needs.[515] The plant received an initial $110 million federal loan to get started. And Australia is now building a 1,000-mile long "electric superhighway" with 18 charging stations to allow seamless travel by electric vehicles along much of the east coast of the country.[516] Additional development and deployment of concentrated solar power (CSP) generation and photovoltaic (PV) use must be subsidized.

Again, government policy instruments to achieve the necessary energy transition include tax, subsidy, and regulation:

- Eliminate all government subsidies currently paid to industries contributing significant carbon emissions - coal, oil, inefficient automobiles, road building and other auto infrastructure, power generation, cement production, livestock agriculture, and forestry – currently about $5 trillion a year;
- Impose substantial new taxes and royalties on all fossil energy production and use: a carbon tax. At minimum governments should immediately impose an additional 20% tax on all coal, oil, fossil-energy power generation, and/or additional end-use (consumer) taxes. A dividend rebate should be instituted for low-income consumers;
- Apply revenues obtained from subsidy elimination and new taxes (target at least 5% of total annual federal budget) toward aggressive investment in the energy transition: energy efficiency, low/no carbon energy alternatives, forest conservation and restoration, non-livestock agriculture, carbon capture and storage initiatives, forest sustainability (reforestation and product substitution), low-emission agricultural practices (no-till grass planting), landfill methane collection, and efficient mass transportation. This revenue stream would exceed the proposed $100 billion-a-year U.N. Green Climate Fund (which has yet to receive significant funding);
- Impose substantial economic and trade sanctions (import duties/quotas, tariffs, and investment restrictions) on countries/industries that do not comply;
- Expand population stabilization initiatives, as it will be easier to provide energy/climate security for 8 billion people than for 11 billion.

During the transition to low/no carbon energy, governments must avoid the following policy alternatives:

- Avoid large-scale investment in hydroelectric generation, as this degrades river ecosystem function, causes significant habitat loss, and adds carbon emissions from reservoirs;

Solar array.

- Avoid large-scale investment in bio-fuel production, as it contributes to extensive loss of biodiversity-rich habitat, often uses untested genetically modified crops, and is intensive in water and chemical use;
- Avoid large-scale investment in nuclear fission power generation, as the technology is too dangerous, generates unmanageable waste, and is terror-prone;
- Avoid any further investment in high-carbon energy resource production, particularly coal, oil, tar sands, and oil shale;
- Avoid investment in large-scale, near-shore tidal energy generation, as damming estuaries and bays disrupts coastal ecosystems.

The sooner we get to the far side of our troubled fossil fuel addiction, the better chance we have at a sustainable future. Then, like most recovering addicts, we will wonder why we didn't get clean sooner.

> *The Stone Age did not end for lack of stones, and the oil age will end long before the world runs out of oil.*
>
> ZAKI YAMANI, FORMER SAUDI ARABIAN OIL MINISTER, 2000[517]

U.S. author Paul Hawken and his associates' 2017 "Project Drawdown" presents a robust, comprehensive, quantitative plan to mitigate and reverse climate change.[518] The Drawdown team assessed the potential benefit to CO^2 reduction of 80 solutions involving refrigeration, wind, solar, reduced food waste, plant-rich diets, transportation, forest protection and afforestation, educating girls, buildings and cities, materials, and recycling; and applied several assumptions to derive a "Plausible Scenario" over the next 30 years. They estimate that their Plausible Scenario could result in 1,051 billion tons of CO^2 avoided or sequestered by 2050, at a net cost of $27 trillion, and provide a net savings of $74 trillion.[519] Drawdown's more aggressive "Optimum Scenario" assumes 100% *clean* (no biomass, landfill methane, nuclear, and waste-to-energy) renewable energy by 2050, which they calculate could reduce atmospheric CO^2 by 1,612 billion tons, with CO^2 drawdown beginning in 2045.[520] It is likely, however, that even in this Optimum Scenario, atmospheric CO^2 levels would continue to increase to 450 ppm and beyond, which would push global temperature beyond the +2°C threshold. As such, we need more aggressive emissions reduction than this. Interestingly, the sector offering the greatest CO^2 reduction opportunity in the Drawdown analysis is food, followed closely by energy. Clearly, Project Drawdown deserves consideration and urgent adoption by all governments and industry.

Reforestation - Reforestation (replanting deforested lands); afforestation (planting forests on lands not previously forested); and high seas kelp farms (permaculture) can absorb huge amounts of CO^2 from the atmosphere.[521] A recent study estimates that restoring lost and degraded forests globally could recapture over 200 billion tons of carbon from the atmosphere.[522] Current global emissions are approximately 10 billion tons of carbon, or 40 billion tons of CO^2 equivalent. The study found that just replanting deforested lands that are not currently used for agriculture or human settlement could increase world forest cover by 30%, and could be the easiest climate mitigation measure to achieve.[523]

Geoengineering – Large-scale climate system interventions, or geoengineering, approaches proposed to fight climate change present the risk of unintended consequences and must be approached with caution. Climate geoengineering technologies can be grouped into either Carbon Dioxide Removal (CDR), also called Carbon Capture and Storage (CCS); and Solar Radiation Management (SRM).[524] CDR consists of carbon capture and removal technologies and is included in most proposed climate change mitigation approaches. This includes Bioenergy with Carbon Capture and Storage (BECCS),

storing captured carbon underground; Direct Air Carbon Capture and Storage (DACCS); and ocean fertilization in which nutrients would be dispersed to ocean waters to increase phytoplankton uptake of CO^2.

Solar Radiation Management (SRM) is more controversial, and less scientifically established. The primary method in discussion for SRM is Stratospheric Aerosol Injection (SAI), in which sulfide gases such as sulfuric acid, hydrogen sulfide, or sulfur dioxide (SO^2)

Cloud vortices over Guadalupe Island, Pacific Ocean, Mexico.

would be released into the upper atmosphere by aircraft, helping to reflect sunlight and mimicking effects of volcanic eruptions. Additional proposals include, Marine Cloud Brightening (MCB) in which salt or other particulates would be released into marine clouds to increased their albedo (reflectivity); Cirrus Cloud Thinning (CCT), involving cloud seeding to disperse high-level cirrus clouds that now trap infrared radiation; and Ground-Based Albedo Modification (GBAM), to increase surface albedo by whitening roofs and covering glaciers or deserts with reflective sheeting.[525] While a few of these methodologies are already in use (e.g., roof whitening), there are considerable concerns about unintended consequences of many of these SRM proposals.

These geoengineering proposals should be carefully evaluated, and tested if, and only if, certain environmental benefits/costs can be conclusively established and all potential consequences understood. In considering geoengineering solutions to climate change, the precautionary principle must apply.

Nuclear Fusion - While nuclear *fission* reactors present many insurmountable challenges (waste, safety, weapons proliferation), nuclear *fusion* seemingly does not. But after billions of dollars spent on research, fusion power technology continues to remain decades away from commercial availability. The International Thermonuclear Experimental Reactor (ITER) now under construction in southern France, a collaborative effort of 35 nations, may be the best hope of perfecting commercial feasibility of large-scale, carbon-free energy based on fusion - the same process that powers our sun and stars.[526] Experimental fusion reactors today can be fueled with deuterium, a heavy hydrogen isotope extracted from seawater. The ITER "Tokomak" experimental reactor is scheduled to begin operation in 2035. These efforts deserve enhanced government support.[527] Another fusion development that deserves attention is that of hydrogen-boron fusion, being advanced by Tri Alpha Energy.[528]

However, a fundamental question remains: if civilization has access to unlimited clean energy, will we be able to exercise restraint in our other environmentally damaging economic activities, such as habitat destruction, resource depletion, and pollution? Historically, increased energy availability and consumption always leads to increased use and depletion of other resources, habitat loss, and pollution. Without restraint, human civilization with unlimited (even clean) energy could easily push the biosphere beyond the sustainability threshold.

Climate Change Adaptation – Even with the current +1°C warming, adaptation needs are extensive. Given the trajectory of emissions and the virtual certainty that we will surpass the +1.5°C threshold, climate adaptation needs will continue to grow. As listed by the U.S. Environmental Protection Agency (EPA), climate change adaptation strategies include the following: ecosystem protection (wetlands, estuaries, coasts, and river systems); water management (response to drought, seawater intrusion, sea level rise, storms and flooding, source water impacts, storm erosion and sedimentation, water runoff, and algal blooms); air quality (indoor, ground level ozone, and particulate matter); and waste management and emergency response (contaminated site management, disaster debris, and extreme heat).[529] Adaptation will also be needed in infrastructure and agriculture. And due to rising sea levels,

hundreds of communities worldwide will need to relocate, costing billions of dollars.

Globally, climate adaptation costs are estimated to exceed $500 billion per year by 2050.[530] It is almost certain that actual adaptation costs will substantially surpass this estimate. The 2016 UNEP Adaptation Gaps report concludes:

> *The adaptation finance gap is large, and likely to grow substantially over the coming decades, unless significant progress is made to secure new, additional and innovative financing for adaptation.*
>
> IBRAHIM THIAW, U.N. ENVIRONMENT PROGRAM, 2016[531]

To fund these increasing adaptation needs, all regional and national governments should establish climate change response funds, derived from a tax on fossil fuels, emissions, or other agreeable fiscal mechanisms.

Cooling Action Plans - Finally, all nations should develop and implement robust "Cooling Action Plans," such as that released in March 2019 by the government of India.[532] The Government of India expects an eight-fold increase in cooling demand over the next 20 years.[533] In response, India's Cooling Action Plan seeks to reduce cooling demand in all sectors by 20% to 25% by 2038; reduce cooling energy requirements by 25% to 40% by 2038; increase cooling technology research; provide sustainable thermal comfort for all residents; lower greenhouse gas (GHG) emissions related to cooling; double farmers' incomes with better cold chain infrastructure; and develop a skilled cooling technology workforce.[534] All nations, particularly those in severe heat stress, should follow suit.

While in the U.S. 90% of households have air conditioners, only 8% of the households in the hottest parts of the world, where 2.8 billion people live, now have air conditioners. The International Energy Agency (IEA) predicts that the number of air conditioners globally will increase three-fold, from 1.6 billion today to 5.6 billion by 2050, adding significantly to electricity demand and warming.[535] Carbon emissions from increased use of air conditioning alone could lead to a 0.5°C temperature increase by the end of the century.[536] It is critical that these additional air conditioners be as energy efficient as possible, which would also save trillions of dollars in operating costs.[537] Urban cooling concepts should be expanded, including more parks, green roofs, water mist showers, fountains, reflection pools, awnings, shutters to reflect sunlight, covered open-air corridors, and smart building design.[538]

Geothermal energy.

Oceans

The Ocean stirs the heart, inspires the imagination, and brings eternal joy to the soul.

ROBERT WYLAND, U.S. MARINE LIFE ARTIST[539]

The goal for ocean restoration and conservation is to eliminate marine pollution, expand protected areas, and reduce marine harvests to sustainable levels in all marine ecosystems. Ocean conservation objectives include the following:

- At least 50% of the world oceans should be protected in no-take marine reserves, free from any industrial use. Today, less than 4% of open ocean habitat and 17% of coastal ocean area is protected in reserves. These new protected marine reserves must not only be in offshore "blue water" pelagic ecosystems (where most to date have been designated), but also in highly productive, heavily exploited coastal continental shelf ecosystems;
- The U.N. Treaty on Biodiversity in Areas Beyond National Jurisdiction (BBNJ) initiated by the U.N. General Assembly December 2017 (an emerging Global Ocean Treaty within the U.N. Law of the Sea) must prioritize conservation over economic development, including strong provisions requiring environmental impact assessments, 50% of high seas in fully protected reserves, prohibition of deep sea mining, and enhanced enforcement of illegal fishing;

Great Barrier Reef.

- Government subsidies for the commercial fishing industry should be eliminated ($15 billion to $30 billion each year);
- Governments must continue and expand their fishing fleet capacity reduction/vessel buyback efforts;
- All fisheries should either receive Marine Stewardship Council or comparable sustainable certification, or be closed;
- Global wild fish catch should be reduced by 50% to allow fish populations and other components of the marine ecosystem (marine mammals, seabirds, sea turtles, and seabed communities) to fully recover and thrive;
- Governments must enhance efforts to enforce regulations and eliminate illegal, unreported, and unregulated (IUU) fishing and destructive fishing practices, including measures to reduce by-catch (e.g., requiring night-setting of pelagic longlines to reduce seabird by-catch).
- Aquaculture must be more conservatively managed, including a shift from marine waters to tank-farm culture on shore;
- Landfills on shore must be managed more effectively, to reduce persistent debris entering coastal seas;
- Use and discard of plastics should be reduced wherever possible, including a global ban on single-use plastics;
- Carbon emissions must be reduced by 80%, to restore sea ice, and reduce warming-induced coral reef decline and acidification;
- Agricultural fertilizer application must be managed more effectively, using buffer vegetation and trees to reduce excessive nutrients from flowing into rivers and to the sea that create dead zones;
- Ships must be designed and retrofitted with ship-quieting technologies to reduce underwater noise;
- All offshore oil drilling and seabed mining should be prohibited by national governments and in international waters under the jurisdiction of the U.N. Convention on Law of the Sea (UNCLOS);
- The U.N. Law of the Sea should be amended to prohibit all extraterritorial continental shelf claims by member states, and in some regions such as the Arctic Ocean, rescind 12 to 200 mile coastal state sovereignty in order to establish an international Arctic marine sanctuary in all waters beyond 12 miles from shore.

Transportation

For the past century, the automobile has been the central organizing force for personal transportation worldwide, and it is now clear that this is unsustainable. Traffic congestion alone is forcing a transition to sustainable mass transport options.

Governments around the world now recognize that the car is the *problem*, not the *solution* to transporting billions of individuals, and are beginning to plan and invest in future non-automobile transportation systems that are environmentally, socially, and economically sustainable. All governments should agree to phase-out the manufacture of fossil-fuel powered cars after 2030.

The U.N. has established the following general principles for sustainable transport:

- Provide safe, reliable, affordable, efficient, people-centric and environment friendly transport systems;
- Avoid unnecessary travel and reduce trip distances: integrating land-use planning and related institutional arrangement, achieving mixed-use development in cities;
- Shift towards more sustainable modes: applying non-motorized transport (NMT) components in transport master plans, improving public transport services and implementation of transport demand management (TDM);
- Improve transport practices and technologies: inducing vehicle technology, fuel quality, freight transport efficiency, inspection and maintenance (I/M), air quality and noise standards; adopting intelligent transport system, zero fatality and energy security policies; monitoring health impacts, adopting social equity, and promoting good governance.[540]

Rapid electrification of global transport will be necessary to reach climate goals of +1.5°C.[541] For individual passenger vehicles, this will include greater fuel efficiency (hybrid and electric), lighter (composite) and smaller vehicles,

Smart cities are now designing efficient human movement into development planning.

more efficient power trains, and stringent emissions controls. This must include all-electric aircraft, such as Eviation's nine-passenger "Alice" referenced in the Energy/Climate section. Some countries, including India, France, UK, Norway, and China (the largest car market today) are planning to prohibit gasoline and diesel powered cars and shift to cleaner electric and hybrid vehicles. The government of Iceland is proposing a ban on cars powered by non-renewables by 2030.[542] The Chinese government is planning to subsidize half of the retail cost of electric vehicles.[543] Several automakers, including Ford and Volkswagen, recently announced that they would be introducing dozens of electric and gas-electric hybrid vehicle models in China by 2025.[544] And some cities (e.g., Sacramento, Los Angeles, Rotterdam, Dallas, Copenhagen, Pittsburg, and Kuala Lumpur) are experimenting with "intelligent traffic management," including sensors imbedded in roadways and traffic light cameras in order to reduce traffic congestion, enhance flow, and reduce fuel use.[545]

But however efficient and clean the individual passenger vehicle may become, the only real solution to sustainable transport, particularly in urban areas, will be non-road mass transport for passengers and freight: electric trains, high-speed passenger rail, integrated port design, and well-planned airports. Traffic congestion alone will preclude individual passenger vehicles being used by 11 billion people, most of whom will live crowded together in cities. Urban design that decentralizes delivery of goods and services will reduce demand for transport. Studies have shown that on-line shopping and delivery can reduce carbon emissions by 80%-90%.[546] While governments have historically subsidized cars and roads, smarter, sustainable options must now be subsidized and/or required.

Some transportation planners predict that individually owned, internal combustion engine vehicles could cease being sold this decade. While there are 250 million individually owned vehicles on U.S. roads now, this number may drop to less than 50 million by 2030, switching instead to "Transportation as a Service" (TaaS) autonomous electric vehicles. That would be as remarkable a transition as the horse-to-car transition in the first decade of the 1900s. By 2030, some transportation planners project that 95% of all miles traveled on U.S. roadways will be on TaaS autonomous electric vehicles, and that the number of cars on roads will decline by about 66%.[547] These planners feel that car ownership will be illogical, at least in cities.

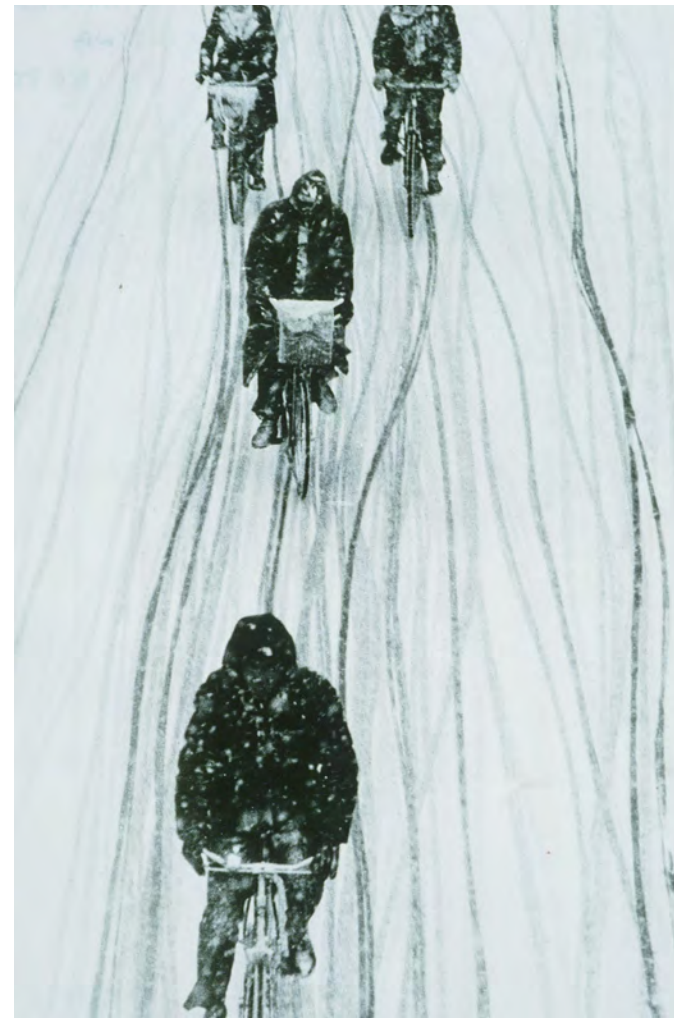
Novel autonomous technologies for "smart city" transport are rapidly emerging. These include the first autonomous aerial quadcopter passenger drone as an aerial taxi service in Dubai; Elon Musk's proposed vacuum tube, magnetically levitated "Hyperloop" intending to move people and goods underground at 700 mph; autonomous delivery robots and aerial delivery drones now being commercially tested; smart streetcar corridors that more efficiently manage traffic; autonomous electric shuttles; and battery-powered "hybrid" commercial aircraft. Such transport and delivery options may change the face of transportation in short order. Virgin's Hyperloop One has signed a contract with Saudi Arabia to build a 35-km test area.[548] One industry official states that Hyperloop will be ten-times more efficient than airplanes, and faster.[549]

All innovative transport technologies should be carefully evaluated, and if they clearly reduce carbon emissions and other environmental impacts, these should be subsidized by governments.[550]

Regarding costs and benefits of the transition to sustainable transport, the U.N. concludes as follows:

> *There are enormous opportunities presented by sustainable transport: saving hundreds of thousands of lives every year through improved road safety and reduced air pollution, and reducing carbon emissions by 7 gigatonnes (billion tons). The transformation to sustainable transport requires a redirection, rather than any substantial increase, in infrastructure expenditure and can be realized through an annual investment of around U.S. $2 trillion. The transition to sustainable transportation can be made with about the same annual expenditure governments now allocate to transport, $2 trillion, but refocused on sustainable options, similar to the current 'business as usual' spending of U.S. $1.4 to U.S. $2.1 trillion. When considering full transport costs, including fuel, operational expenses, losses due to congestion, and vehicles, sustainable transport can deliver savings of U.S. $70 trillion by 2050.*
>
> U.N. MOBILIZING SUSTAINABLE TRANSPORT FOR DEVELOPMENT, 2016[551]

Electric vehicles are rapidly replacing fossil fuel powered vehicles.



Nuclear Disarmament

Complete, global nuclear disarmament is a fundamental responsibility for modern society. A full-scale nuclear exchange could end human civilization and have enormous, long-lasting, global environmental impact. A central goal for a stable, sustainable, peaceful future must be to eliminate all nuclear weapons and secure all nuclear material. Building nuclear weapons was a political choice seeking to achieve strategic dominance and perceived security. Now, the only rational choice for future security is to dismantle and eliminate all such weapons.

Ever since the first Nuclear Non Proliferation Treaty (NPT) entered into force in 1970, disarmament has steadily proceeded, yet with difficulty. In 1985, Soviet Premier Mikhail Gorbachev proposed to eliminate all nuclear weapons, and made unilateral concessions, saying that "parity" was meaningless with such an overkill of these devastating weapons. The U.S. and the Soviet Union agreed to the Intermediate-Range Nuclear Forces (INF) Treaty in 1987 (of concern is that this treaty was rescinded by both parties in 2019); the Strategic Arms Reduction Treaty (START) in 1991; 3,000 warheads were returned to Russia by former Soviet states after the 1991 dissolution of the Soviet Union; START II in 1993, with each side committing to reduce stockpiles to 3,500 warheads by 2003; the Comprehensive Test Ban Treaty (CTBT) in 1996; the 2002 Strategic Offensive Reductions Treaty (SORT) also known as the "Treaty of Moscow," to reduce deployed strategic warheads; the Global Threat Reduction Initiative (GTRI) in 2009, seeking to secure and reduce vulnerable nuclear and radiological materials from possible acquisition by terrorists; and the 2011 New START treaty. New START remains in effect until 2021 and requires a reduction of deployed warheads to 1,550 and deployed missiles and bombers to 1,500 for both the U.S. and Russia. We must achieve this goal, and go further.[552]

US/Russia nuclear arms negotiations, 2017.

Dismantled Soviet nuclear bombers.

Today, we still have more than 13,000 nuclear weapons scattered across the world, with a combined yield 360,000 times greater than the Hiroshima bomb - more than enough to end civilization as we know it.

While governments (mostly the U.S. and Russia) have spent over $5 trillion to build nuclear weapons, it will take only a fraction of that to secure and dismantle them. The singular goal for all governments must be to eliminate all nuclear weapons – period, full stop. This can be done in a verifiable manner, with economic, political, and trade incentives.

On the way to achieving the ultimate goal of global denuclearization, several steps should be taken to reduce risk of a nuclear exchange, including:

- Take all nuclear weapons off hair-trigger alert;
- Detach all warheads from delivery systems to reduce risk of accidental launch;
- Continue the deployed weapons reductions agreed in New START;
- Dismantle all withdrawn warheads;
- Stop producing plutonium and encase all existing plutonium;
- Phase-out all ICBMs and cancel the new nuclear-armed cruise missile;

US stealth nuclear bomber.

- Secure and eliminate all short-range nuclear weapons;
- Incentivize North Korea to discontinue its weapons program and continue the Iran nuclear deal;
- Focus specific attention on preventing a nuclear exchange between India and Pakistan, which would cause a humanitarian crisis in south Asia;
- Continue to implement GTRI, convert reactors from highly enriched uranium (HEU) to low-enriched uranium (LEU), dispose of all excess nuclear and radiological materials, and protect high priority nuclear and radiological materials from theft and sabotage;
- Rescind unilateral authority for national leaders to launch a nuclear attack, without the consent of their national legislative body (e.g., Congress in the U.S.).

So far under the GTRI, all HEU materials have been removed from 18 countries, and thousands of spent fuel assemblies and several tons of enriched uranium have been returned to the U.S.[553] These efforts deserve continued, focused political attention and support.

Speaking on the threat of nuclear war at the height of the Cold War in 1963, U.S. President John Kennedy said:

> *So, let us not be blind to our differences - but let us also direct attention to our common interests and to the means by which those differences can be resolved. And if we cannot end now our differences, at least we can help make the world safe for diversity. For, in the final analysis, our most basic common link is that we all inhabit this small planet. We all breathe the same air. We all cherish our children's future. And we are all mortal.*
>
> U.S. PRESIDENT JOHN F. KENNEDY, 1963[554]

World Scientists' Warning to Humanity: A Second Notice

Oddly enough the overriding sensation I got looking at the Earth was, my god that little thing is so fragile out there.

MICHAEL COLLINS, APOLLO II ASTRONAUT, 1969[555]

The 2017 "Second Notice" on environmental decline from over 15,000 scientists endorsed most of the environmental goals discussed here. The Scientists' Second Notice calls for the following urgent actions needed to transition to sustainability:

(a) prioritizing the enactment of connected well-funded and well-managed reserves for a significant proportion of the world's terrestrial, marine, freshwater, and aerial habitats; (b) maintaining nature's ecosystem services by halting the conversion of forests, grasslands, and other native habitats; (c) restoring native plant communities at large scales, particularly forest landscapes; (d) re-wilding regions with native species, especially apex predators, to restore ecological processes and dynamics; (e) developing and adopting adequate policy instruments to remedy defaunation, the poaching crisis, and the exploitation and trade of threatened species; (f) reducing food waste through education and better infrastructure; (g) promoting dietary shifts towards mostly plant-based foods; (h) further reducing fertility rates by ensuring that women and men have access to education and voluntary family-planning services, especially where such resources are still lacking; (i) increasing outdoor nature education for children, as well as the overall engagement of society in the appreciation of nature; (j) divesting of monetary investments and purchases to encourage positive environmental change; (k) devising and promoting new green technologies and massively adopting renewable energy sources while phasing out subsidies to energy production through fossil fuels; (l) revising our economy to reduce wealth inequality and ensure that prices, taxation, and incentive systems take into account the real costs which consumption patterns impose on our environment; and (m) estimating a scientifically defensible, sustainable human population size for the long term while rallying nations and leaders to support that vital goal.

WORLD SCIENTISTS' WARNING TO HUMANITY, A SECOND NOTICE, 2017[556]

Government, industry, and others ignored the first world scientist's call to action 25 years ago, and our environmental predicament has gone from bad to worse. It is imperative that this second (perhaps final) call to action is heeded.

United Nations Sustainable Development Goals

> *No place on the planet can remain an island of affluence in a sea of misery. We're either going to save the whole world or no one will be saved.*
>
> MAURICE STRONG, SECRETARY GENERAL OF 1992 RIO EARTH SUMMIT[557]

The success of many of the U.N. Millennium Development Goals (MDGs) directed at poverty reduction is a testament to the power of government commitment. The eight goals, established in 2000 targeting achievement by 2015, included:

1. Eradicate extreme poverty and hunger.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.
6. Combat HIV/AIDS, malaria, and other diseases.
7. Ensure environmental sustainability.
8. Develop a global partnership for development.[558]

It remains difficult to distinguish cause and effect in this complex of issues, and certainly some of the reported progress was achieved due to underlying demographic and macroeconomic trends, and not from top-down goal setting. Some of these goals were not achieved, including eradication of extreme poverty and providing universal primary education.

Importantly, the goal of environmental sustainability remains far from being achieved; in fact, today it is considerably more distant than it was in 2000. This failure alone will render impossible the achievement of all socioeconomic goals. We have to be honest about what we have accomplished and where we continue to fail.

Regardless, in 2015, the U.N. reported significant progress toward some of these socioeconomic goals:

- In the past 25 years, the number of people living in extreme poverty has declined by more than half; falling from 1.9 billion in 1990 to 836 million in 2015. More than 1 billion people have been lifted from extreme poverty;
- Primary school enrollment has increased from 83% in 2000 to 91% in 2015, yet there are more than 57 million children that do not go to any school;
- Literacy rates among young people aged 15-24 have increased to 91%, and the gap between women and men has narrowed (yet almost 1 billion adults remain illiterate). As educational levels increase, fertility declines, agricultural productivity increases, and disease decreases;
- Many more girls are now in school compared to 15 years ago, and gender disparity has decreased;
- Women now make up 41% of paid workers outside the agricultural sector, an increase from only 35% in 1990. The proportion of women in parliaments has nearly doubled in the past 20 years;
- The under-five mortality rate was cut by more than half between 1990 and 2015. The number of children under five dying each year declined from 12.7 million in 1990 to 6 million in 2015;
- Maternal mortality has declined by 45% since 1990;
- New HIV infections have declined by 40% since 2000, from 3.5 million to 2.1 million;
- Since 2000, the incidence of malaria has fallen by 37%, and the mortality rate by 58%. Over 900 million insecticide treated mosquito nets were provided to malarial-endemic countries in sub-Saharan Africa;

- The tuberculosis mortality rate fell by 45%;
- Over 2 billion people gained access to improved drinking water and sanitation (but still half of the world population does not have such access);
- Internet penetration has increased from 6% of world population in 2000 to 43% in 2015 (3.2 billion people). And 95% of the world population is now covered by a mobile-cellular signal.[559]

Despite this progress, the U.N. assessment also noted the persistence of serious gender inequality, a severe income gap between rich and poor, 800 million still living in extreme poverty and hunger, continued severe environmental decline, a 50% increase in carbon emissions since 1990, a four-fold increase in the number of refugees from conflict just since 2010; 16,000 children under five years old dying every day due to preventable causes; and 946 million people lacking basic sanitation facilities and who still practice open defecation.[560] Worryingly, reduction in poverty has been achieved largely at the expense of the environment. This cannot continue.

As Mahatma Gandhi once said: "The world is big enough to satisfy everyone's need, but not everyone's greed."[561]

At the conclusion of the Millennium Development Goal initiative in 2015, U.N. member nations adopted a new 2030 Agenda for Sustainable Development, a set of 17 Sustainable Development Goals (SDGs) with 169 specific targets.

The 2030 U.N. Sustainable Development Goals (SDGs) are:

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote well-being for all, at all ages.
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. Achieve gender equality and empower all women and girls.
6. Ensure availability and sustainable management of water and sanitation for all.
7. Ensure access to affordable, reliable, sustainable and modern energy for all.
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
10. Reduce inequality within and among countries.
11. Make cities and human settlements inclusive, safe, resilient and sustainable.
12. Ensure sustainable consumption and production patterns.
13. Take urgent action to combat climate change and its impacts.
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.[562]

It must be noted that the U.N. 2030 goals do not include stabilizing human population. This intentional and conspicuous omission is troubling, as it would make

the achievement of any of the goals more difficult. Clearly, it would be easier to achieve these goals with 8 billion people rather than 11 billion (or more) people.

In its 2019 Sustainable Development Goals (SDG) Report, the U.N. notes progress on many of these, but worrisome lack of progress on others. The following is the U.N. Secretary General's statement in the report:

> *The report demonstrates that progress is being made in some critical areas, and that some favorable trends are evident. Extreme poverty has declined considerably, the under-5 mortality rate fell by 49 per cent between 2000 and 2017, immunizations have saved millions of lives, and the vast majority of the world's population now has access to electricity. Countries are taking concrete actions to protect our planet: marine protected areas have doubled since 2010; countries are working concertedly to address illegal fishing; 186 parties have ratified the Paris Agreement on climate change, and almost all have communicated their first nationally determined contributions. About 150 countries have developed national policies to respond to the challenges of rapid urbanization, and 71 countries and the European Union now have more than 300 policies and instruments supporting sustainable consumption and production. And a wide range of other actors—international organizations, businesses, local authorities, the scientific community and civil society—have engaged with the SDGs in a manner that generates great hope for the coming decade. The United Nations, for its part, is working hard to reposition to the United Nations development system to be better equipped to meet the needs of governments to respond to this integrated and transformative agenda.*
>
> *Notwithstanding that progress, this report identifies many areas that need urgent collective attention. The natural environment is deteriorating at an alarming rate: sea levels are rising; ocean acidification is accelerating; the past four years have been the warmest on record; one million plant and animal species are at risk of extinction; and land degradation continues unchecked. We are also moving too slowly in our efforts to end human suffering and create opportunity for all: our goal to end extreme poverty by 2030 is being jeopardized as we struggle to respond to entrenched deprivation, violent conflicts and vulnerabilities to natural disasters. Global hunger is on the rise, and at least half of the world's population lacks essential health services. More than half of the world's children do not meet standards in reading and mathematics; only 28 per cent of persons with severe disabilities received cash benefits; and women in all parts of the world continue to face structural disadvantages and discrimination.*
>
> *It is abundantly clear that a much deeper, faster and more ambitious response is needed to unleash the social and economic transformation needed to achieve our 2030 goals.*
>
> U.N. SECRETARY-GENERAL ANTONIO GUTERRES, 2019[563]

Again, the "Doing Good Insufficiently" paradox. We simply have to do better. If we fail to achieve the overarching goal of *environmental* sustainability, none of these *socioeconomic* goals will be met. It would be game over. These goals can be achieved only if governments urgently commit the financial resources and political will needed, and we the people need to demand this.

This is the central challenge of our present break*down* or break*through* decade. ●

V

CONCLUSION:

From Anthropocene to Ecocene

System collapse has a remarkable way of freeing one's mind from old conceptions.

LESTER MILBRATH, ECONOMIST, 1989[564]

Earth is a sublime, self-sustaining spaceship carrying us all through the dark uninhabitable vacuum of the universe. But due to our selfish actions, the biosphere is now in system collapse, and it is time we recognize this and free our minds to act on solutions, such as those outlined here in *Oasis Earth*. Inevitably, the current Anthropocene era will evolve into the ecologically sustainable Ecocene.[565] The current trajectory of environmental and social decline cannot continue much longer. The Anthropocene will be gone in a blink of geologic time. The real question now is what will be left of the biosphere at the dawn of the Ecocene, and whether *H. sapiens* will survive. The biosphere will recover, with or without humanity.

It is useful to imagine the stratigraphic signature that will be left from the Anthropocene, perhaps to be explored a million years from now by whatever intelligent life forms might remain or visit. The Anthropocene-Ecocene (A-E) stratigraphic boundary may consist of a thin layer of black carbon, ash, and other combustion products from the trillions of tons of fossil fuel burned in a few centuries; remnant anthropogenic metal items; sediment from anthropogenic land use changes; artificial radionuclides such as Plutonium 239; plastic debris; concrete; higher levels of nitrogen and phosphorous from excessive fertilizer use; and trace elements like mercury from coal combustion.

The A-E boundary will be as prominent and identifiable as the K-T (Cretaceous-Tertiary) boundary that marks the impact of the Chicxulub asteroid 65 million years ago. The K-T boundary can be found across the Earth surface, infused with iridium from the vaporized asteroid, and shocked quartz and glass spherules from the impact. As the K-T boundary marks the last (pre-human) mass extinction event, when Earth lost most large vertebrates, including the dinosaurs, the A-E boundary will mark the current Anthropocene mass extinction.

If the present trajectory of the Anthropocene continues, the transition to the Ecocene may not begin for over a century. In that scenario, more than half of the 10 million or so species on Earth today will be extinct, including *H. sapiens*. As with other mass extinction events in the history of the biosphere, biodiversity will recover over the following 5-10 million years, and a new stable ecological state will emerge. But humanity would not be part of that sustainable future.

Alternatively, if we are successful *this decade* in reversing the interconnected drivers of decline – population, resource consumption, habitat loss, biodiversity loss, and economic inequality - the Ecocene transition could begin by mid-century.

If we want our species to be part of the sustainable future, this must be our goal.

> *Our institutions, too, move at a clip incommensurate with nature. The modern news cycle endures one day; the political horizon stretches a few years; even resource management plans rarely exceed a decade or two.*
>
> *These temporal mismatches impede our ability to meet the challenges of conservation. The coming decade represents a window of opportunity: We could choose to set aside and recover wildlife habitat, trim our carbon emissions, purchase products from sustainable harvesting, and demand that our leaders and professionals strive to improve people's lives in the long run.*
>
> JAMES SCHAEFER, PROFESSOR, 2019[566]

We need to set our collective sights on transitioning to the Ecocene by 2050, or sooner. This will involve stabilizing human population at a sustainable level (by reducing birth rates); clean, sustainable, no-carbon energy and transportation systems; stabilized climate, with atmospheric CO^2 levels declining to 350 ppm, temperature held to only +1.5° or +2.0°C above historic baseline; half of Earth's ecological habitat (marine, freshwater, terrestrial) in protected status; sustainable agriculture; an equitable, circular, zero-waste global economy, with closed-loop materials sourcing; peace, prosperity, food, freshwater and health for all; no nuclear weapons; and no fragile and failed states.

We pay for what we value, and we have to value the preservation of life on this extraordinary planet. All of the environmental and social goals necessary to achieve sustainability can be achieved if, in addition to strong environmental regulation and enforcement, the G20 governments have the political will to provide an emergency 10-year investment of $1 trillion per year for environmental sustainability and $1 trillion per year for socioeconomic sustainability. The longer we wait to make this investment in sustainability, the more it will cost, and the more difficult it will be to achieve. We can either pay a little now, or a lot later, or we will not survive.

Again, as our collective efforts over the past 50 years have not halted or reversed global ecological decline, and we have at most 10 years left to redirect this disastrous trajectory, it is urgently necessary to try new approaches. Again, as Albert Einstein warned: "We can't solve problems by using the same kind of thinking we used when we created them."[567]

Below is a summary of what we need to do by 2030, even beyond the U.N. goals:

Will we survive the transition from the Anthropocene to the Ecocene or just leave a trace of carbon and radioactive materials at the stratigraphic boundary?

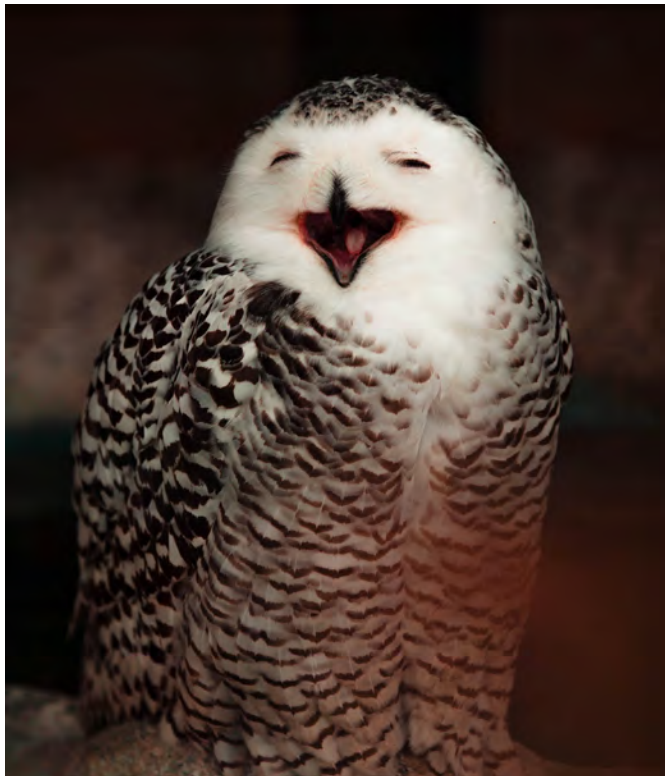
Oasis Earth Agenda 2030

Population

Achieve zero population growth with voluntary, non-coercive reduction in birth rate, and stabilize population at a sustainable level; fully fund and ensure access to family planning and reproductive health programs in developing countries, including access to contraceptives; provide universal primary education; and provide full paid employment for all.

Biodiversity

Reduce the extinction rate to the pre-human background level (1,000-times lower than today); guarantee strict enforcement of protected areas; strictly prohibit/enforce all trade in protected species; enhance seed bank preservation of plant biodiversity; reduce spread of invasive species; strengthen legal protections for endangered species; ban trophy hunting globally; impose a moratorium on potentially dangerous genetic engineering practices, and develop an international convention to regulate such.



Protected Areas

Place half of all land surface, and half the ocean in reserves fully protected from industrial activity; immediately protect all biodiversity hot spots on land and in the ocean; purchase conservation easements on privately owned lands where necessary; protected areas must include representatives of all ecoregions - tropical forests, temperate/boreal forests, taiga, arctic tundra, grasslands and savannas, deserts, shrub lands, rivers and river deltas, coral reefs, estuarine ecosystems, continental shelves, high seas, and polar and sub-polar marine ecosystems; and ensure effective enforcement, involving local communities.

Habitat Restoration

Restore and re-wild degraded ecological habitats, including forests (tropical, temperate, boreal), coastal seas, rivers and lakes, wetlands, and prairies.

Forests

Eliminate deforestation, accelerate reforestation/afforestation; protect all remaining old growth forests; ensure protective buffers around protected forests; replant and restore deforested areas; require sustainable forestry on all managed forests; carefully manage intensive plantation production; and reduce timber demand with alternative product substitution.

Oceans

Place half of the ocean in protected status; establish a U.N. Global Ocean Treaty for high seas (international waters), and national laws protecting coastal seas (currently only 4% of high seas and 17% within nationally managed coastal seas are protected); these new marine protected areas must include productive continental shelves and offshore pelagic ecosystems, tropical, temperate, and polar oceans; reduce the global wild fish catch by 50% (to under 50 million tons per year); eliminate all fishery subsidies; eliminate by-catch (marine mammals, fish, seabirds, and turtles); practice sustainable aquaculture production with tank farm systems; increase enforcement of illegal, unreported, and unregulated (IUU) fishing; eliminate plastic debris (subsidize effective land-based waste management) and other ocean pollutants; prohibit deep sea mining; and prohibit extraterritorial shelf claims under U.N. Law of the Sea.

Freshwater

Subsidize/require efficient (drip) and "smart" irrigation; reduce industrial use and waste; improve efficient residential water use and reduce waste; restore river flows for ecological function, delta deposition, and wetlands; prohibit construction of more large dams, remove dams from ecologically productive waterways; and reduce agricultural runoff with more efficient, smart fertilizer application.

Energy

Decarbonize the global energy economy; require/subsidize clean, renewable energy production (Green New Deal); tax carbon, require/subsidize a five-fold increase in energy efficiency in all sectors; incentivize 80% of fossil fuel reserves remaining in ground and seabed; prohibit offshore and Arctic oil/gas development.

Climate

Reduce carbon emissions by 50%; atmospheric CO^2 levels approach peak and begin decline toward the 350 ppm goal; temperature rise less than +1.5°C; increase carbon capture; halt deforestation, increase afforestation (planting new forests) and reforestation; reduce livestock husbandry by 50%; and carefully explore geoengineering solutions, but test only if clear environmental benefit/cost is established and all potential consequences are well understood; fully fund adaptation efforts, including community relocation and cooling action plans.

Transportation

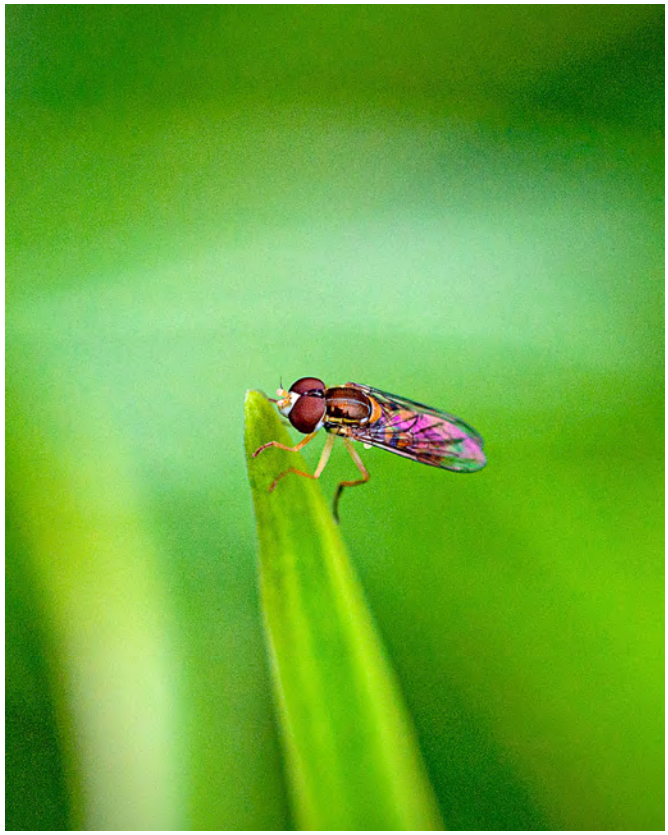
Accelerate the phase-out of fossil fuel-powered automobiles; subsidize/require renewable-powered electric vehicles; subsidize efficient, electric mass transport in urban areas; subsidize telecommuting; tax/prohibit inefficient transport and delivery systems.

Food and Agriculture

Subsidize the shift to sustainable practices, no-till farming, recycle crop waste and manure, and soil conservation; farm and consume lower on the food chain, and subsidize and encourage plant-based food production and meat/dairy substitutes; reduce number of livestock and meat/dairy consumption by at least 50%; impose a 20% sales tax on all meat/dairy; reduce chemical fertilizer use and runoff; plant drought-tolerant crops; prohibit production and use of harmful pesticides (such as neonicotinoids and sulfoxaflor harmful to bees); subsidize organic farming; and improve efficient food preservation and distribution systems to eliminate food waste.

Nuclear Weapons

Immediately take all nuclear weapons off hair-trigger alert, then eliminate nuclear weapons altogether; stop producing highly enriched uranium and plutonium; establish rigorous compliance verification regimes with stiff penalties for non-compliance.



Economy

Achieve an efficient, circular, zero-waste, stable, and equitable economy (using tax and subsidy instruments); sustainable consumption; increased revenue sharing and other assistance to fragile and failed states; and refocus on economic *stability* rather than *growth*.

Social Development

Achieve all U.N. Sustainable Development Goals (Section IV).

Policies for Sustainability

Government: *Tax* destructive activity (carbon, habitat loss, pollution); *Eliminate* perverse/damaging subsidies; *Subsidize* sustainable alternatives; *Regulate/prohibit* destructive activity, require sustainability; *Enforce* environmental laws and regulations.

Industry: Sustainability certification for all industries; Zero-waste, closed-loop, circular material sourcing; Net zero carbon energy use; Transparency, environmental directors on boards; At least 1% of annual profits donated to environmental causes.

Consumers: Reduce ecological footprint; Buy green, travel green, eat green, invest green; Engage with government and industry re: sustainability.

Financing: To achieve the Oasis Earth Agenda 2030 and U.N. goals listed above, significant additional government funding is required, as below:

National Budgets: From 2020-2030, G20 governments (now producing over 80% of world GDP) should appropriate a minimum of 5% of their annual budgets specifically to the transition to domestic environmental sustainability (e.g., for the U.S., $250 billion per year; China, $150 billion per year, and so on).

Living Planet Emergency Fund: Additionally, from 2020-2030, G20 governments must provide emergency international financial assistance to the other 170 governments of the world, of $1 trillion per year in *environmental* assistance, and $1 trillion per year in *socioeconomic* assistance.

A worldwide emergency investment of at least $2 trillion per year from 2020-2030, a total of $20 trillion, for international environmental and socioeconomic assistance is urgently needed, and would represent only about 3% of world GDP. This 10-year Emergency Fund can be derived from a 3% national assessment on the economies (GDP) of each G20 nation, with annual funding including (roughly): U.S., $600 billion; China, $400 billion; Japan, $150 billion; Germany, $140 billion; India, $90 billion; and so on. If governments need to deficit-spend to allocate this amount, so be it. The ecological debt we are accruing is far more dangerous than our financial debt. Alternatively, these funds can be raised by simply eliminating and reappropriating the environmentally damaging (perverse) subsidies currently paid by governments, now totaling more than $5 trillion each year. The Living Planet Emergency Fund can be managed by existing institutions, such as the U.N./World Bank Global Environment Facility (GEF).

To put it bluntly, without such dedicated emergency funding, we will soon have a desolate planet with no future for humanity. But with this level of emergency investment, together with stronger environmental regulation and enforcement, we can save the future of humanity and our living Home Planet. That's quite the return-on-investment.

The central lesson of Rapa Nui (Easter Island) is that people were unable to recognize the unsustainable trajectory of their lifestyle until it was too late and were unable to act cooperatively to alter their course.

Collapse of Rapa Nui: A Cautionary Tale

Finally, although still not fully understood today, the collapse of Polynesian society on Rapa Nui (Easter Island) around 1,600 A.D. provides an instructive context for us to think about our current environmental situation.[568] A cautionary tale, indeed.

As described by noted anthropologist Jared Diamond and others, sometime between 400 A.D. and 1,200 A.D., Polynesians arrived on Rapa Nui, over 2,000 miles from the nearest continent. The settlers found a lush forest, wood for fuel and building, fertile soil, and abundant marine resources. They planted typical Polynesian crops – taro, sweet potatoes, bananas, and sugar cane – and harvested fish and porpoises (for which they built robust, seaworthy canoes built from the now-extinct large Easter Island palm tree), seabirds, land birds, and chickens for food. Their prosperity provided free time with which they carved 80-ton rock "moai" statues to honor their ancestors, and the island population is thought to have peaked at between 7,000 and 20,000 people, organized into cooperative tribal communities.[569]

But then, as Diamond describes, archaeological evidence shows that the population quickly exceeded the environmental carrying capacity of the island and coastal ecosystem. The island was deforested, cleared for agriculture, firewood, building material, and materials to transport the carved moai from the quarries to platforms miles away. Without large trees, offshore harvests became impossible due to their inability to build seaworthy canoes, rainwater runoff and erosion increased, freshwater became scarce, and soil fertility declined. The settlers had also inadvertently introduced Polynesian rats to the island, which multiplied rapidly and became voracious grazers on palm seeds. And as native birds were killed for food, seed dispersal and flower pollination declined. As with other Polynesian islands, many island species became extinct. By 1,500 A.D., without forests, islanders turned to burning grass and eating rats; tribal warfare, starvation, and cannibalism broke out; and the population plummeted. Today, Rapa Nui is one of the classic stories of human ecological overshoot and environmental collapse.

At some point in the history of Rapa Nui civilization, some observant islanders must have recognized that the population was using resources in an unsustainable manner and that they needed to better manage resources collectively to survive. While some must have expressed this warning, most likely discounted and ignored such warnings altogether. As Diamond speculates: "...any islander who tried to warn about the dangers of progressive deforestation would have been overridden by vested interests of carvers, bureaucrats, and chiefs, whose jobs depended on continued deforestation."[570]

As resources declined, and it became clear that their civilization was headed for collapse, warfare broke out between tribes competing for what was left. At some point, it would have become obvious that the once-prosperous civilization would not survive. The moai were all torn down, and the culture collapsed.

The central lesson of Rapa Nui is that people were unable to appreciate the unsustainable nature of

their lifestyle until it was too late and were unable to act cooperatively to alter their certain course toward oblivion.

Today, our global civilization is at precisely this same existential crossroad: many recognize that we are exceeding the carrying capacity of Earth's biosphere; have sounded the alarm; yet political momentum continues toward catastrophe. As Diamond concludes:

> *By now the meaning of Easter Island for us should be chillingly obvious. Easter Island is Earth writ small. Today, again, a rising population confronts shrinking resources. We too have no emigration valve, because all human societies are linked by international transport, and we can no more escape into space than the Easter Islanders could flee into the ocean. If we continue to follow our present course, we shall have exhausted the world's major fisheries, tropical rain forests, fossil fuels, and much of our soil by the time my sons reach my current age.*
>
> JARED DIAMOND, ANTHROPOLOGIST, 2005[571]

As on Rapa Nui centuries ago, many people and governments today continue business-as-usual, consuming as we have for decades, ignoring the scientific certainty of the dire consequences of our current unsustainable path. The central question before us today is whether we are capable of making rational decisions to save our civilization and the biosphere, or not.

On this, Diamond noted a crucial, encouraging difference between the Easter Island collapse and our prospects today:

> *The Easter Islanders had no books and no histories of other doomed societies. Unlike the Easter Islanders, we have histories of the past - information that can save us. My main hope for my sons' generation is that we may now choose to learn from the fates of societies like Easter's.*
>
> JARED DIAMOND, ANTHROPOLOGIST, 2005[572]

That must be the hope for us all.

Today, global civilization is at this same existential crossroad as Rapa Nui. Many recognize that we are exceeding the carrying capacity of Earth's biosphere and have sounded the alarm, yet political momentum continues toward catastrophe.

Our One and Only Home

It suddenly struck me that that tiny pea, pretty and blue, was the Earth. I put up my thumb and shut one eye, and my thumb blotted out the planet Earth. I didn't feel like a giant. I felt very, very small.

NEIL ARMSTRONG, APOLLO II, VIEWING EARTH FROM THE FIRST WALK ON THE MOON, 1969[573]

On February 14, 1990, the Voyager spacecraft photographed Earth from 4 billion miles away, one of its final assignments as it left the contiguous solar system. In the now famous image, Earth is a dim, small blue crescent, awash in a stream of diffuse sunlight in the darkness of space. It is one of the most haunting images ever taken of our precious blue and white Home Planet, awe inspiring and frightening at once.

Of that image, noted astronomer Carl Sagan wrote:

Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves.

There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known.

CARL SAGAN, ASTRONOMER, 1994[574]

Earth is our one and only home.

As the Taoists say: "The paths are many, but their end is one." That end, we hope, will be a sustainable, peaceful, prosperous world for all human and non-human life on Earth. This shift to sustainability would be as dramatic a shift as the agricultural, industrial, and technological/information revolutions.

The good news is that many people the world-over now recognize the severity of the environmental crisis and intend to solve it. In 1968, U.S. civil rights activist Eldridge Cleaver said: "If you're not part of the solution, you're part of the problem."[575]

There are no Passengers on Spaceship Earth: We are all Crew.

ART FOR SCIENCE RISING, 2019[576]

Lester Brown echoed this sentiment, reminding us that: "Saving civilization is not a spectator sport."[577] This effort will take everyone from all walks of life: scientists, artists, poets, writers, musicians, film producers, journalists, industry leaders, government officials, farmers, religious leaders, laborers, entertainers, athletes, financiers, non-governmental organizations, young and old - everyone.

Our one and only home.

A Letter to the Future

In 2019, the Prime Minister of Iceland and others placed a "memorial shield" at what once was the Okjokull ("Ok") glacier, reading:

> *A Letter to the Future*
>
> *Ok is the first Icelandic glacier to lose its status as a glacier. In the next 200 years, all our glaciers are expected to follow the same path. This monument is to acknowledge that we know what is happening and what needs to be done. Only you know if we did it.*
>
> AUGUST, 2019; 415PPM CO^2 [578]

As much as the Ok memorial is a "Letter to the Future," it is also a direct challenge to present day civilization. Similar memorials could be placed at dead or threatened forests, coral reefs, estuaries, glaciers, grasslands, and other ecosystems across the world.

Ok Glacier, Iceland, 2019.

It is important to realize that we know exactly what needs to be done to fix this crisis. We all know instinctively how to take care of ecosystems and each other. The problem is not a lack of information, but rather a lack of motivation. Finding this motivation right now is the single most important challenge in the history of humanity. As historian Barbara Tuchman observed: "Wisdom is the exercise of judgment acting on experience, common sense and available information."[579]

One way to think about our actions now is: what will people think 50 years from now about the choices we make/made today? Knowing what we know now, what more could we have done back in 2020 to avert disaster? As Shakespearean scholars have observed, the main difference between a comedy and a tragedy is that, in a comedy the characters recognize reality in time to do something about it. The question before us now is: will we?

Our evolutionary history indicates that *H. sapiens* is remarkably adaptable, and when threatened, we respond. As always, our evolutionary imperative remains: evolve or die. If a large asteroid were headed toward Earth, governments, industry, and the public would recognize the danger and unite to take swift, cooperative action in defense of our imperiled, common future. The present environmental crisis is every bit as much of a threat – indeed more so, as it is actually upon us.

We need to transcend the Anthropocentric paradigm of "me-first" materialism, neurotic hoarding of resources, "my net worth equals my self-worth," "I-am-what-I-own," and viewing nature as simply another exploitable commodity, in favor of the emerging Ecocentric paradigm. In addition to causing extraordinary environmental damage, Anthropocentrism has failed to provide the emotional fulfillment and contentment promised. An Ecocentric worldview respects all living beings as sentient companions with inalienable rights, rather than exploitable commodities. After all, as descendants of LUCA – the Last Universal Common Ancestor – all organisms on Earth are distant relatives.

In the coming critical decade, we should keep our "eyes on the prize": a sustainable society that meets its needs while protecting the quality of life of future generations of all species; a society that is just and equitable, where corporations are servants of the public interest, not masters of it; a society that provides education, health care, employment, leisure, the arts, and personal security; and a society in which we can all enjoy wild spaces and natural ecosystems in all their splendor, and learn what they have to teach us. Every single individual of every species on Earth is, in a very real sense, an improbable, incomprehensible miracle, and should be respected as such.

While we don't know everything, we do know that we are all here together at this precise point in space-time, traveling together through the sublime mystery of the cosmos. We also know that Earth will soon transition from the Anthropocene to the Ecocene, with or without *H. sapiens*. Whether humanity will be a part of the Ecocene is now up to us.

> ***To see the earth as it truly is, small and blue and beautiful in that eternal silence where it floats, is to see ourselves as riders on the earth together, brothers on that bright loveliness in the eternal cold—brothers who know now they are truly brothers.***
>
> ARCHIBALD MACLEISH, POET, 1968[580]

If we do manage to transcend Earth's contemporary "Great Filter" of environmental collapse and remain part of the biosphere into the Ecocene, our descendants will travel long and far together.

And what a ride that will be. ●

It may take 5 to 10 million years for the biosphere to fully recover from the current Anthropocene extinction. The future biosphere will be significantly different than the past, but recover it will.

The history of the possible end or survival of humanity is being written right now, right here, by us. If we manage to transcend Earth's Anthropocene environmental collapse and remain part of the biosphere into the Ecocene, our descendants will travel long and far together. What a ride that will be.

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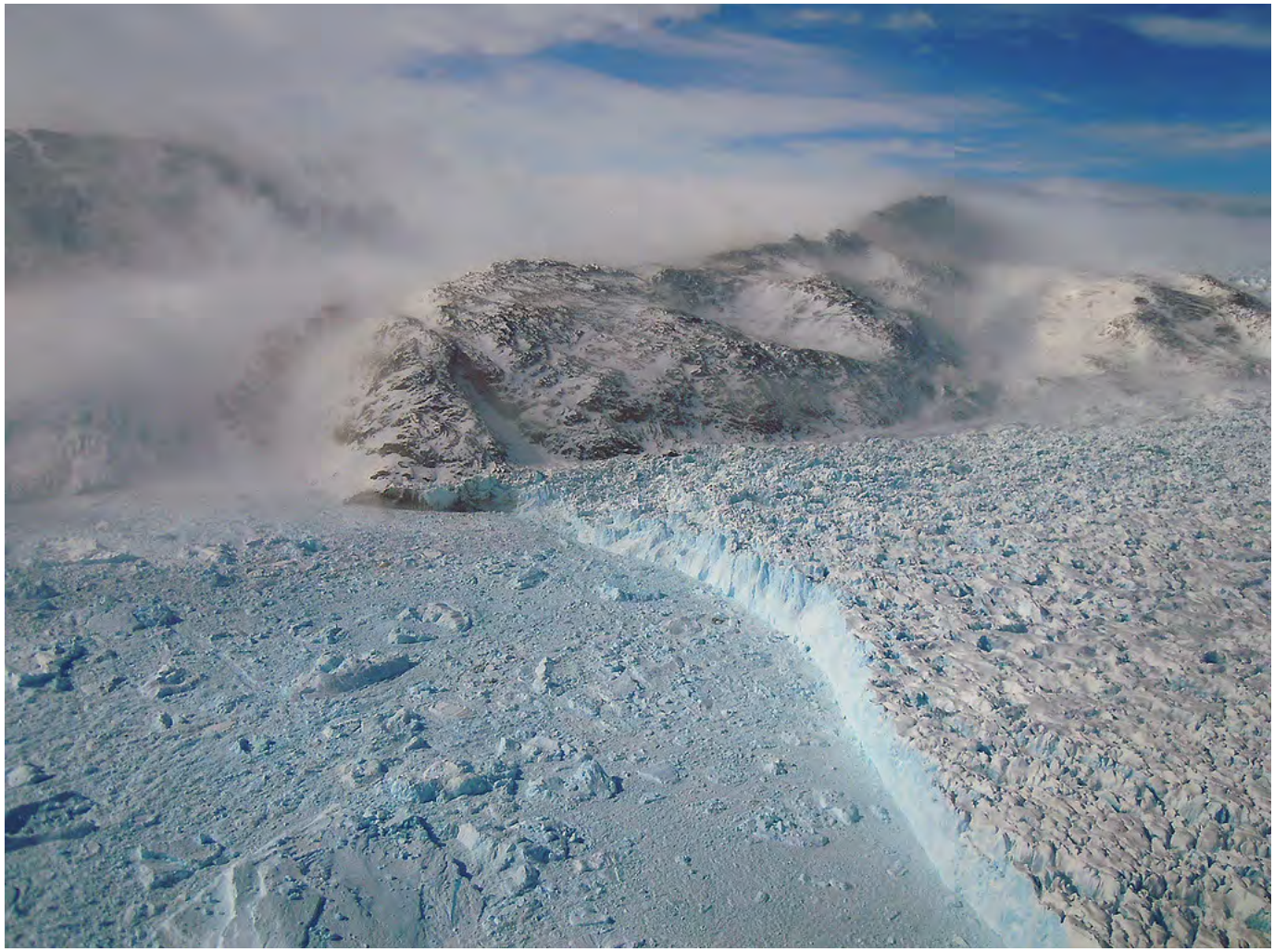

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x. Deforestation at PT Megakarya Jaya Raya (PT MJR) Oil Palm Concession in Papua, Southeast Asia; 2018; Ulet Ifansati/Greenpeace

xi. *top*: Samadai Reef, Red Sea, Egypt; 2006; Marco Care/Greenpeace;
bottom: Clearing Summer Storm; Brian Fiske, USA; UNEP

xii. *top: Misty Seascape; Photographer Unidentified; UNEP*
bottom left: Life; Miyamato Tatsuo, Japan; UNEP
bottom right: Boudhayan Bardhan; Unsplash

xiii. *Earth Rise, Apollo 8, 1968; NASA*
Contents: Arctic Sea Ice, Beaufort Sea, Alaska; Kelley Elliott; 2005; NOAA/OAR/OER Hidden Ocean

I. Introduction

1: *first: Cost of Progress; Bhudev Bhagat, India; UNEP; second:* Coal Fired Power Plant in Rhenish Lignite Mining Area, Germany; 2014; Bernd Lauter/ Greenpeace

3. Colour, Hot Spring; Jin Huei Luo; UNEP

4. Rainforest on Fire, Sumatra, Indonesia; 1997; L. Lily/Greenpeace

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7. The Day After; Joel Rocha, Brazil; UNEP

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About the Author

Rick Steiner is a conservation biologist in Anchorage, Alaska, and has been involved in the global conservation movement for over 40 years. From 1980-2010 he was a marine conservation professor with the University of Alaska, stationed in the Arctic, Prince William Sound, and Anchorage, specializing in marine conservation, and worked on environmental effects of offshore oil, climate change, fisheries, marine mammals, habitat conservation, and conservation policy. After the university and the U.S. government pressured him to restrain from raising concerns about the risks and impacts of offshore oil development, he resigned his tenured professorship in protest. He has authored over one hundred publications; written commentaries for many national and international media outlets including *USA Today, LA Times, The Guardian,* and *Huffington Post;* and worked around the world with governments, the United Nations Environment Program (UNEP), the International Union for the Conservation of Nature (IUCN), and many Indigenous People's and non-governmental organizations in diverse regions including Nigeria, Papua New Guinea, Russia, Pakistan, China, the Middle East, the South Pacific, Australia, the Arctic, Kazakhstan, Indonesia, and El Salvador. He has received several conservation awards, and *The Guardian* called him "one of the world's leading marine conservation scientists," and "one of the most respected and outspoken academics on the oil industry's environmental record." He serves on the Board of Directors of Public Employees for Environmental Responsibility, and the Board of Advisors of The Ocean Foundation. He has delivered *Oasis Earth: Planet in Peril* as a public presentation for over 30 years, in many venues around the world.

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Oasis Earth confirms that we are destroying the biosphere of our Home Planet. We know the causes, consequences, and solutions to this existential crisis, yet we've failed to correct it. We are out of time: this decade is our last best chance to save a habitable Earth. Rich with insights from those who have viewed our planet from space and evocative images from the U.N. Environment Program's international photographic competitions, NASA, Greenpeace and others, *Oasis Earth* weaves a journey through the extraordinary diversity of life on Earth, the interrelated causes of global ecological collapse, and the path to a livable future.

Oasis Earth *is a remarkable summary of the miracle that is life on the earth. At the same time, it describes how our ignorance is violating this phenomenal mystery, and instructs us as to who and what we need to become if we are to reverse our collective madness.*

Paul Hawken, author of *Drawdown* and *Blessed Unrest*

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Mark Brooks, WWF-Canada

The window of opportunity is closing. What we do, or fail to do, in the next decade will determine the fate of life on Earth and human civilization. Oasis Earth *illuminates the way forward with the light of beauty, reason and hope.*

Kierán Suckling, Executive Dir., Center for Biological Diversity

Rick Steiner is a conservation biologist and retired professor from the University of Alaska. He advises civil society organizations and governments around the world on ecological conservation and sustainability.

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