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NATURE'S NEWSLETTER

SPECIAL ONLINE EDITION

GLOBAL WARMING AND THE ENVIRONMENT

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The *Delaware Valley Eagle Alliance*

ABOUT THIS SPECIAL ISSUE

The Delaware Valley Eagle Alliance is committed to increase awareness, understanding and promote conservation of our wildlife and the natural environment. This Special Issue features articles about global warming and the environment written by experts in the field and one by students.

We hope you enjoy reading these very interesting, relevant and compelling stories.

Yoke Bauer DiGiorgio, Editor

INSIDE THIS ISSUE

FRONT COVER PHOTOGRAPHY

Front	© Raymond Baltar, Photographer
Insert Left	© Courtesy Dr Michael White
Insert Right	© Courtesy Dr Michael White

DISCOVERING NATURE

© Kristin Bolcarovic, Photographer

"ARCADIA EARTH"
an amazing museum in NYC!

by Kristin Bolcarovic
Elementary School Teacher, Essex County, New Jersey

Did you know that unsustainable fishing patches destroy enough species in the ocean to fill 153 garbage trucks every hour? It wasn't until my recent visit to Arcadia Earth in Manhattan, New York that my eyes were opened to this both shocking and discouraging fact. Arcadia Earth, a pop-up museum that uses augmented reality, virtual reality, and artwork in hopes of inspiring action on recycling and climate change, is a must see!

As a teacher, I can only do so much within the confines of my classroom to demonstrate why it is SO important to recycle. Sure, I can show a video or read an article about why it is a priority. I can even go over steps with students on how to live and dispose of waste more responsibly. However, visiting the museum truly immerses you into what our world will be like in years to come (if we do not do something about garbage and climate change now). Students, or any member of the public, can truly live the experience.

The 15 interactive rooms take you on an incredible journey where you learn about ecological issues such as food waste, pollution, and climate change. If all children were afforded the opportunity to visit this museum, I believe they would gain enough knowledge to start doing their part to help minimize the footprint we are leaving on the environment. It all starts with understanding.

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Photo by Alexey Sukhariev on Unsplash

Biomimicry is a result of a creative and collaborative process that realizes synergies between all design disciplines and produces thoughtful, intelligently-integrated work inspired by nature.

NATURE'S SOLUTIONS ARE ALL AROUND US

by Lex Amore
Biomimicry Specialist, Biomimicry Institute

So what is Biomimicry?

Biomimcry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies. The goal being to create products, processes, and policies—new ways of living—that are well-adapted to life on earth over the long haul. Nature has already solved many of the problems we are grappling with. Animals, plants, and microbes are ingenious engineers. After billions of years of research and development, failures are fossils, and what surrounds us is the secret to survival.

The Biomimicry Institute was founded in 2006 by Janine Benyus and Bryony Schwan to share nature's wisdom with the people who design and make our world. The team began by working directly with educators from K-12, university, and non-formal (museums, zoos, aquariums) environments to naturalize biomimicry in the educational system, and ensure the next generation of changemakers had the tools to integrate biomimicry in their careers.

Our mission at the Biomimicry Institute is to promote collaboration and support a regenerative ecosystem by advancing nature-inspired design through education and application. Basically, we want to empower everyone, everywhere to have access and the ability to practice biomimicry so we can truly make a cultural shift toward one that fits in with nature and is healed by its offering of connection and hope for finding the solutions to the challenges we face.

Our Programs / Initiatives Include:

AskNature.org
This free community resource offers solution seekers time-tested strategies for creating design that is circular, regenerative and resilient. The online curated library features over 1,700 biological strategies and hundreds of nature-inspired ideas - and it's growing! For over half a million people each year, AskNature is the place they go to find the blueprints for resilient design for a circular economy.

continued on page 4

continued from page 3

NATURE'S SOLUTIONS ARE ALL AROUND US

© www.biomimicry.org

2019 Ray of Hope Prize Winner
WatchTower Robotics
Boston, Massachusetts

Watchtower uses a next-generation, flexible robot to inspect water pipes, locating leaks for utilities to easily fix.

The strategy is to build a robot that is like a squid or gecko; it leaves behind a piece at every leak it finds in an underground water pipe. This piece has a beacon effect that allows maintenance crews to locate it with wireless scanners from above ground, pinpoint the location of the leaks, and know where to dig and fix them.

Biomimicry Youth Design Challenge
A project-based learning experience that asks middle and high school students to design nature-inspired ideas that can provide solutions to the climate crisis. We offer free educational tools and professional training for teachers so they can bring the classroom outside. Registration for the 2019-2020 Biomimicry Youth Design Challenge is now open. Please visit our website for more information and to sign up as a teacher or coach.

Biomimicry Global Design Challenge
An annual team competition that addresses critical sustainability issues with nature-inspired solutions. The 2020 Challenge, which just opened this month, is calling on participants to create solutions focused on the United Nations' Sustainable Development Goals. Participants of the Challenge are able to hone their biomimicry skills with access to free tools in an 8-week syllabus, trainings and mentor support, and are able to practice creative problem solving inspired by nature's genius.

Finalists selected by the expert jury are eligible to join the Biomimicry Launchpad program, where they will be provided assistance in bringing their solutions to the global marketplace.

Biomimicry Launchpad
An accelerator program that helps early-stage entrepreneurs bring nature-inspired solutions to market. It consists of a virtual 10-week customer discovery and technology validation "pre-accelerator" and an in-person Biomimicry & Business Expedition, this year in Panama. The Launchpad will cover topics such as the biomimicry design process, understanding a customer's problem or need, and how to build a rockstar team.

Ray of Hope Prize®
The Ray of Hope Prize® is a competition that provides top biomimicry startups with connections, media exposure, and funding to accelerate their path to commercial success. At the end of each competition cycle, one team is awarded the $100,000 Ray of Hope Prize, in partnership with the Ray C. Anderson Foundation. This prize is awarded to the most viable prototype that embodies the radical design principles of biomimicry and Ray's legacy of sustainable success.

Global Biomimicry Network
We connect thousands of nature-inspired innovators across the world, working to practice, teach, and spread biomimicry in their region. The purpose of the global, regional and professional networks is to spread the practice and philosophy of biomimicry and to apply that knowledge to design opportunities that create nature-inspired solutions for a healthy planet. We will be relaunching this project in 2020 with a new platform for our network.

We also have a blog – **"asking NATURE"** which shares news and ideas from the Biomimicry global network.

Examples of Biomimicry in Action:

Restoring Native Forests
With deforestation contributing an estimated 15% of greenhouse gas emissions, countries, NGOs, and

© Photo provided by Nucleário

continued on page 5

continued from page 4

NATURE'S SOLUTIONS ARE ALL AROUND US

innovators are mobilizing to restore our planet's forests as quickly as possible to avoid catastrophic global warming. A Brazilian team of entrepreneurs looked to the bromeliad to see how it captures water and provides a microclimate that attracts (and protects) biodiversity to design an all-in-one reforestation solution.

The Nucleário solution reduces maintenance costs and improves seedling survival rates. Nucleário can get more trees in the ground in less time, helping make it possible to achieve environmental goals like the Bonn Challenge and the Paris Agreement.

Reducing Ocean Plastic

Plastic waste infiltrating our oceans has been a hot topic for the past couple years as fear has mounted in the wake of 'garbage islands' and organisms snacking on harmful, hard to breakdown materials that should never have entered their ecosystem.

What began as a design project for school, the Floating Coconet turned into a true nature-inspired, Biomimicry Global Design Challenge finalist concept. Floating Coconet aims to capture plastic pollution in rivers before it has the chance to enter the oceans. By mimicking the way organisms like manta rays and basking sharks filter food from water, the Floating Coconet is able to collect and direct free-flowing plastics, small and large in size, in rivers for safer capture.

Youth and Climate Action with Biomimicry

With the Biomimicry Youth Design Challenge, we're offering biomimicry tools to young minds, and they're bringing creative solutions to the table. Team Futuristas out of Rhinebeck, NY set out to limit the amount of water flooding a courtyard in their village. They researched several organisms that channel, remove, absorb, store and filter excess water and combined what they learned. Their permeable surface design is a tile that mimics the Hottentot bread's corky outer surface for permeability, the roots of the Black Grama Grass for filtering, and the shape of the Bromeliad and Pitcher plants to drain, channel, capture, and store water.

KimHeam Team from Irvine, CA went on a scuba diving trip near the California Kelp Forests to find inspiration for a more efficient design to harness wave energy. They

TOP: © Provided by Floating Coconet
CENTER: © Provided by KimHeam Team
BOTTOM: © Provided by Team RHS Biomimicry

continued on page 6

continued from page 5

NATURE'S SOLUTIONS ARE ALL AROUND US

© Provided by Team Futuristas

designed a flexible energy generator that mimics the bending movement of kelp blades and transforms it into electrical charges through piezoelectricity. Inspired by the flow patterns of schooling fish, the synthetic kelf forest maximizes potential for energy-generation.

And Team RHS Biomimicry from Larkspur, CA were inspired by the shape and aerodynamic performance of the giant seeds of the Javan cucumber, which led them to design a new passively controlled "tidal kite" for undersea electrical generation. Applying the biomimicry process allowed the teens to look through a different lens in viewing the natural environment while working to solve for the energy demands of their present and future.

With the climate strikes taking kids out of their classrooms to demand action for a better future, we're hoping to bring the classroom to them outside. They're asking for solutions, for hope, and for action now. We want to help them see that solutions are right outside their window.

Nature gives us hope and a pathway for innovation
The solutions are all around us, and that gives us hope that we can take on this climate crisis together. Nature has taught us that those that adapt, survive. There are so many elders we can look to for inspiration in solving the same challenges we face.

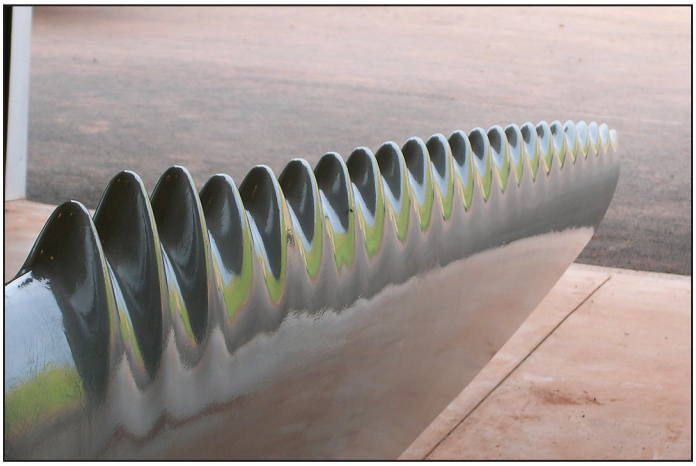
Biomimicry is a result of a creative and collaborative process that realizes synergies between all design disciplines and produces thoughtful, intelligently-integrated work inspired by nature. Together we can act on the climate crisis using sustainable, regenerative solutions that are inspiring, creative and work toward supporting a balanced ecosystem.

Leaders like NASA, Nike, Leonardo DiCaprio and Bill Gates are paying attention. These are not some hoped-for miracle technologies. Proof of concept exist, and biomimicry gives us bold answers to our greatest problems and show us new ways in which humanity could thrive.

We believe that between the forest and ocean floor hides unthinkable solutions to so much more.

Nature's laboratory is showing us the future of possible innovation and transforming the way we live and survive on this planet. We just need to pay attention and connect the dots!

For more information:
https://biomimicry.org/
https://asknature.org/



TOP: *Photo by Todd Cravens on Unsplash*
BOTTOM: *Photo provided by WhalePower Corporation*

INSERT: *Dr Mike White at replanting site.* ***RIGHT:*** *The forest at Akasusa is severely impacted by climate change.* *© Photograph courtesy Dr Michael White*

CLIMATE CHANGE

by Dr Michael White

Marine Zoologist / President of Hakono Hararanga Inc. (Tongareva Community Environmental Society)

Modern *Climate Change* is being driven by people and our daily activities, especially burning fossil fuels. Some people deny that we have anything to do with causing global warming, but the science is crystal clear: it is basic chemistry and physics. Coal, gas, diesel and other fuels are hydrocarbons. The hydrogen burns and carbon combines with oxygen to produce carbon dioxide (CO_2): it is that simple. The greater the concentration of CO_2 in the atmosphere, the warmer our world becomes.

Sunlight arrives as ultraviolet (u/v), which keeps our world warm enough to live on (-14º Celsius / 7º Fahrenheit without sunlight). Earth radiates heat energy back out as infra-red, but this cannot pass through the cloud layer and most is reflected back down again. This is the *greenhouse effect*. Water vapour is also a greenhouse gas (GHG); there are a few others such as nitrous oxide and methane.

Carbon Footprints are a way to show the impact of a person, organization or particular activities. We calculate this by multiplying the **amount of fuel** used and the appropriate **Emissions Factor**. We can report this as ***kgCO$_2$e*** (*e* stands for equivalent, so we can use the same values for other GHGs). Some examples are:

1 litre of fuel (equals 0.264 gallons)	kgCO2e
Jet fuel	3.5
Diesel	2.7
Gasoline	2.3
Propane	1.5

It is obviously harder to figure out your Carbon Footprint for things like air travel, or buying power from a coal-fired utility. The important message is to understand your personal contribution and try to reduce it. We have 7.7 billion people on our planet now: five times more than a century ago. We are all part of the global climate problem. Just about everyone uses fuel in some way.

Historically, the USA has been the world's largest polluter and by its own admission the Pentagon is the largest producer of GHGs in the world (Crawford 2019).

https://watson.brown.edu/costsofwar/files/cow/imce/papers/2019/Pentagon%20Fuel%20Use,%20Climate%20Change%20and%20the%20Costs%20of%20War%20Final.pdf

One way to think about the greenhouse effect is that every CO_2 molecule added to the atmosphere worsens the

continued on page 8

continued from page 7

CLIMATE CHANGE

problem, every molecule saved eases it. Carbon dioxide mixes easily and travels world-wide in about five days; it can persist for hundreds of years. Methane is worse but shorter-lived. The measurement we use is *parts per million* (ppm).

Step back into history for a moment. At the start of the Industrial Revolution in 1750, when Scottish inventors made steam-driven machines powered by coal: atmospheric CO_2 was 280 ppm. In 1900 CO_2 concentration was 310 ppm: an increase of only 30 ppm in 150 years that included the first public railroad (Stockton-Darlington 1825); Karl Benz's motorcar (1855); and Rudolph Diesel's compression ignition engine (1899). The Wright Brothers powered-flight came along in 1903. In May 2019 global CO_2 concentration is **415 ppm**.

So what can we do about it? Deep Decarbonisation can be accomplished by:

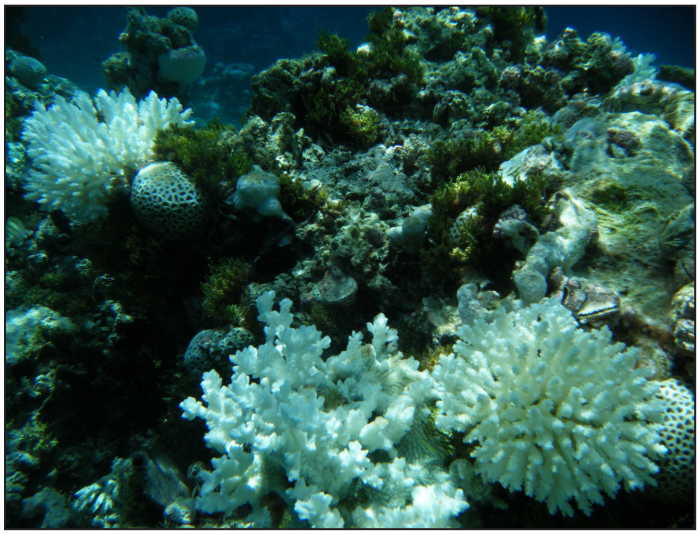
- Use less fuel / plan journeys better and avoid needless travel.
- Switch to less polluting fuels / changing from diesel to propane, biodiesel, or even better electric vehicles.
- Remove CO_2 from the atmosphere and ocean / tree-planting is a simple method. Carbon capture and storage (CCS) is more complex.

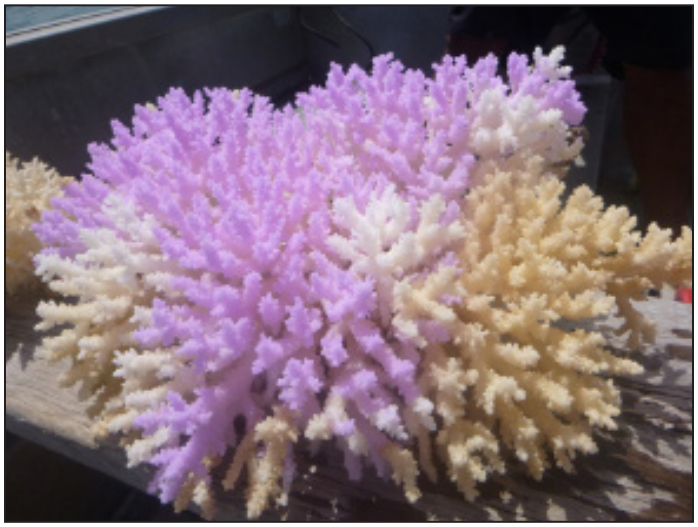
Now let's take a look at the ocean:
For the last half-century around 90% of excess heat energy has entered the ocean, and about 30% of emitted CO_2. It is no surprise that these have changed ocean chemistry and its physical properties. Heat energy is stored beneath thermoclines, but can re-emerge as the strata shift or overturn.

El Niño Southern Oscillation (ENSO) is a phenomenon driven by atmospheric and oceanographic conditions in the Pacific Ocean. It raises sea temperature, changes current flows, trade-winds and rainfall patterns. Unfortunately it impacts global events, including increased wildfires in Indonesia and Australia. Its *La Niña* phase tends to be cooler. In 2019 we are in a neutral phase with *El Niño* soon. Strong *El Niños* were unknown in nature before 1982.

Corals
Corals are colonial animals that have tiny *zooxanthellae* living inside their dermal tissue; these symbionts photosynthesise carbon to produce sugars for the coral host. When sea temperatures rise, zooxanthellae food production increases until it becomes toxic (free radicals), so corals eject them leaving the *bleached* carbonate structure. Coral polyps might still be alive at this point, but rely on filter-feeding; however, there may be insufficient dermal cells left to provide proper nutrition.

Tongareva Atoll
The longest *El Niño* on record occurred between April 2015-





© Photographs courtesy Dr Michael White

***TOP:** Coral bleaching in January 2019 caused by u/v radiation as sea temperatures are normal. **CENTER:** Bleaching at depth during 2016 El Niño ~ water temperature was 38°C. **BOTTOM:** Stages of bleaching ~ brown is normal, lilac (and other vivid hues) indicates stress, white is bleached.*

continued on page 9

continued from page 8

CLIMATE CHANGE

May 2016. Tongareva Atoll (09º S; 158º W) suffered for five months. Lagoon temperature was 38º Celsius for weeks and nearshore ocean 34ºC (White 2016). The entire 77 km of the outer reef bleached, as did every patch reef in the 233 km^2 lagoon. Worse still was 95% of giant clams (*Tridacna maxima*) died too: they also have zooxanthellae in the mantle. Clams are an important food resource for us: we control harvest using *rahui* (traditional ecosystem management). This terrible tragedy killed many thousands of shellfish. In 2018 a few clams appeared.

Because Tongareva had been near pristine the outer reef corals began to recover. January 2019: the author discovered bleaching again, but this time seawater was cooler. Increased u/v radiation is the likely cause. Greenhouse gases that contain bromines or chlorines degrade the stratospheric ozone layer and more sunlight enters. This bleaching event provided excellent research opportunities and we monitored the changes as they occurred; in 2016 bleaching had happened before we found it. A simple tool is the CoralWatch health card (*www.coralwatch.org)*: *citizen science* from University of Queensland, Brisbane. We noticed corals showed vivid hues, a sign of sickness, before bleaching. Branching corals became more brittle and broke off, then plate corals too. In June 2019 the boulder corals began to recede and many disappeared! Interestingly, clams seemed unaffected.

Coral decalcification could be a consequence of increased ocean acidification. As CO_2 accumulates in the ocean, carbonic acid is formed (low pH). Carbonate ions needed for reef building become less available, also calcium carbonate structures start to dissolve (reefs and shells). A two-pronged attack on a vital ecosystem that sequesters huge volumes of carbon.

Is anything else happening? Unfortunately, yes!
The *Inter-decadal Pacific Oscillation* (IPO) occurs over longer time-scales than ENSO: it also has a negative and positive phase. We are heading towards a simultaneous IPO+ and El Niño, but the backgound temperature is already warmer. Perhaps sea surface temperatures could reach 40ºC. Increased tropical storms are likely.

Warmer oceans melt polar ice. Loss of sea ice, glaciers, and permafrost reduces *albedo* so that more irradiance is absorbed instad of being reflected (positive feedback loop). Sea level can rise from meltwater and thermal expansion.

Warmer seawater holds less oxygen, forcing mobile species to seek cooler, deeper water; sessile life will likely die. *Dead Zones* are either hypoxic or anoxic and becoming more common globally.

The sex of sea turtle embryos is determined by nest incubation temperature: females from warmer eggs, males from cooler ones. Research projects around the world are

© Photographs courtesy Dr Michael White
***TOP:** Top: Green sea turtle Chelonia mydas swimming underwater. **CENTER:** Dead turtle embryo around mid-term development. **BOTTOM:** Tallying success rate of a hatched turtle clutch, only 4 of 188 eggs didn't succeed.*

starting to report feminisation of embryos due to a warming climate. Tongareva is the paramount sea turtle habitat in the central South Pacific (White 2014).

Increased u/v irradiance seems to be causing severe leaf

continued on page 10

continued from page 9

CLIMATE CHANGE

loss in tree species, and pollen is becoming unviable. In turn foliage loss creates problems for nesting birds, as there is no shade.

Insects, especially bees, are disappearing in many places.

Alien invasive species are spreading rapidly, often because of global trade, indigenous species tend to be outcompeted. As habitats fail species have no place to go.

Plastics are a byproduct of the oil industry. The ocean is full of plastics. Corals in contact with plastics are much more susceptible to disease (Lamb et al 2018).

The most disturbing concern for scientists now is the rate of change: events and cascade effects are occurring so much faster than models predicted. Even if we stopped using fossil fuels today, we've already locked in changes that will continue for centuries. Ecosystems can reach *'tipping points'* in which they flip into a completely new, irreversible, state.

How do we fix our world?

During December 2015 almost every country in the world signed the Paris Agreement (United Nations Framework Convention on Climate Change); USA subsequently withdrew. The stated aim was *to limit global temperature rise to well below 2ºC compared to the pre-industrial age*.

Another key convention is *'Agenda 2030: Transforming our world'*. This consists of 17 Sustainable Development Goals (SDGs) and 169 targets. Signatories must do all SDGs, not cherry-pick a few easy ones. Goal 13 is climate action; Goal 14 life below water; Goal 15 life on land. Importantly, a response to one goal or target should not worsen another.

Sadly, USA has the greatest *per capita* Carbon Footprint: **17 tonnes CO_2e per annum.** China is 8 tonnes CO_2e per annum; India 4 tonnes CO_2e per annum. It is true that China has the biggest overall emissions, but its population is 1.5 billion compared with USA's 326 million. All of America's wars are to do with oil (Iraq, Libya, Syria; Venezuela and now Iran). It is unsurprising that CO_2 emissions are rapidly increasing.

One further piece of legislation is the Majuro Declaration (2013) where a group of *highly ambitious* countries (many of them Pacific Island nations at great risk of being submerged by rising sea levels) determined *to limit global temperature rise to below 1.5ºC.* We are already close to that limit.

All five previous mass-extinction events had GHGs as their proximate cause; most emissions were from volcanic activity and occurred over millions of years. The present (6th) extinction has humans as the driving force. The rate of increase of CO_2 levels is deeply disturbing. We might quibble over a small fluctuation (2 or 3 ppm) in the short term concentration, but looking back over one million years, the increase now is vertical. [we have data from rock strata, ice-cores, corals, tree rings etc].

TOP: *Much oceanic plastic is manufactured consumer goods.* ***CENTER:*** *Plastic bottles are everywhere.* ***BOTTOM:*** *Chairman Ru Taime and Dr Mike White sorting rubbish collected from lagoon ~ none is from our atoll.*

continued on page 11

continued from page 10

CLIMATE CHANGE

LEFT: *Dr Mike White teaching university students at Linosa, Italy.* ***RIGHT:*** *Tagging blacktip reef shark Carcharhinus melanopterus at Tongareva 2018*

© Photographs courtesy Dr Michael White

https://www.stockholmresilience.org/

In 2009 the Stockholm Resilience Centre produced the **Planetary Boundaries** concept as *a safe operating space for humanity*. It categorised the world into nine fundamental zones with increasing risk as each boundary margin is exceeded. Biodiversity has long been lost but gained hardly any political interest. Climate change is a much better motivator as it affects money and profit.

Let us be crystal clear: it is an overwhelming task to shift our world from a highly-polluting fossil fuel based economy, to one that runs on clean energy. Yet change we must. It is very likely we have missed the opportunity to mitigate the ravages of climate change, so now we must learn to adapt to the consequences of our inaction. We can call this the *procrastination principle*: each year of delay makes it harder to achieve the Paris Accord goals. The technology we need already exists; including to refreeze the polar regions (Sir David King, Climate Repair Institute).

For readers who find it hard to make up their minds about climate change, especially any man-made contribution, I suggest reading the IPCC reports. These are conservative, cautious, and explain their confidence levels. Science is based on facts:

https://www.ipcc.ch
https://www.carbonbrief.org/state-of-the-climate-heat-across-earths-surface-and-oceans-mark-early-2019

Do we honestly believe that 250 years of Industrial Revolution have had no effect upon our planet?

It is for us to choose the sort of planet we want: a healthy, abundant, biodiverse and sustainable world, or a rapidly warming and failing biosphere.

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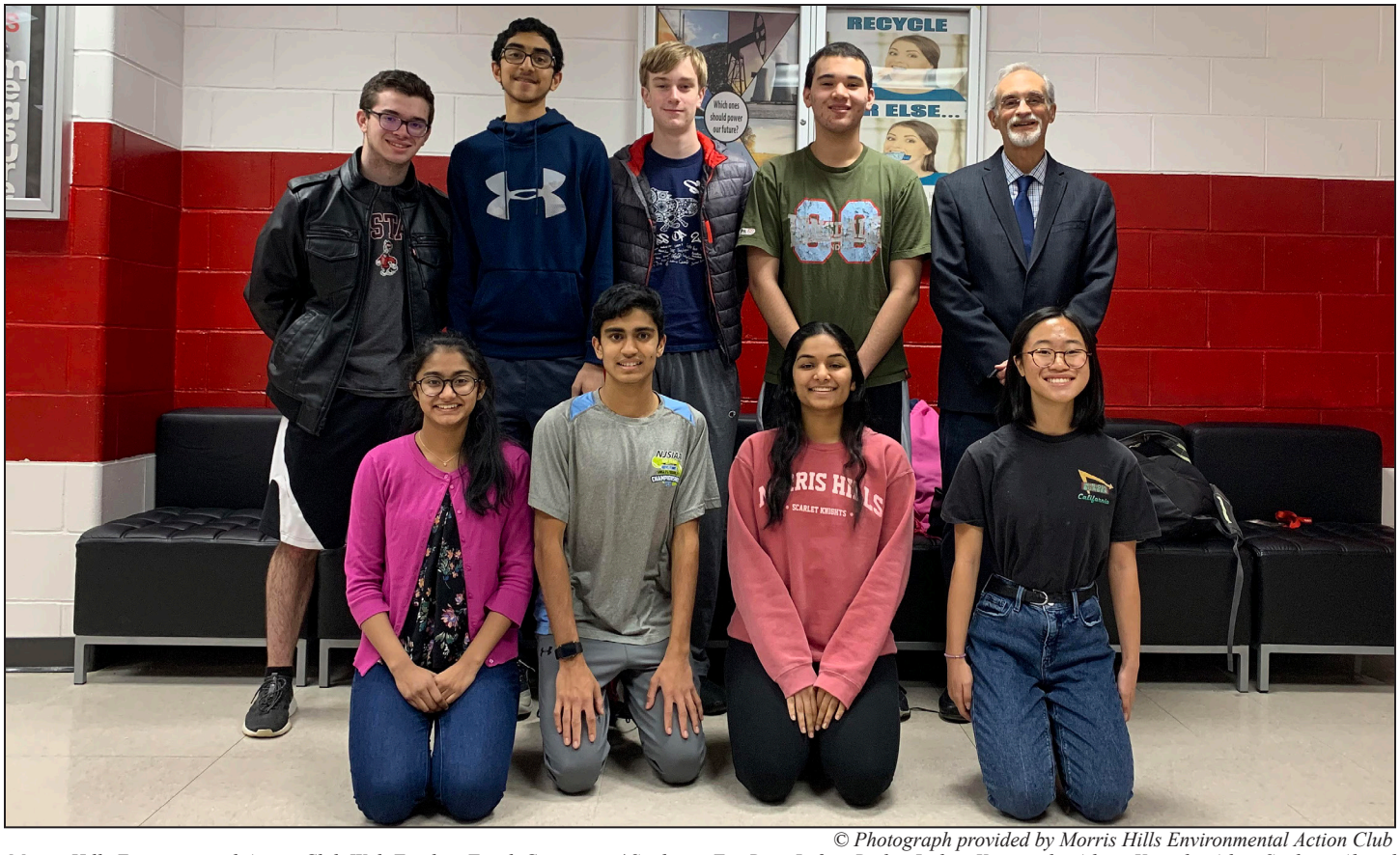
An interesting story on California: https://www.theguardian.com/commentisfree/2019/oct/29/has-the-climate-crisis-made-california-too-dangerous-to-live-in

ABOUT DR MICHAEL WHITE

a Marine Zoologist who has studied endangered sea turtles for over 25 years. He lives on Tongareva Atoll in remote Oceania where the people lead a subsistence way-of-life gathering resources directly from nature. Impacts of climate change are now a severe threat.

President of Hakono Hararanga Incorporated, Tongareva's Community Environmental Society. Works with local education, scientific research, collecting oceanic plastics from the uninhabited islets, tree-planting and forest-restoration (planted over 6000 trees in the last 18 months).

A Fellow of the Marine Biological Association of Great Britain. A Member of the IUCN Species Survival Commission: Marine Turtle Specialist Group. ***https://hararanga.org***



© Photograph provided by Morris Hills Environmental Action Club

Morris Hills Environmental Action Club With Teacher, Frank Cappuccio / Students: Top Row, Left to Right: Joshua Yagozinski, Aditya Kasarla, Adam Simkins, Ahmed Elsayyid. Bottom Row, Left to Right: Rupa Kurinchi-Vendhan, Neel Godbole, Roma Patel, Amelia Wong.

TOO MANY BLANKETS!

How Greenhouse Gases Are Overheating Our Planet

by Morris Hills Environmental Action Club
Morris Hills High School, NJ

Carbon dioxide (CO_2) is not the villain some make it out to be. If there was no CO_2 in the atmosphere the average temperature of the Earth would be 0 °F, cold enough that the oceans would be frozen over and life probably would not have started on Earth. However, with CO_2 at a level of .04% of the atmosphere, then the average temperature is now at a comfortable level of about 60 °F.

So, what is the problem? The problem is that CO_2 levels are now too high and rising. Measured in parts per million (ppm) our level today is way too high. Charles Keeling measured CO_2 levels in the 1950s and saw they were increasing.

The Earth is used to typical cycles of warming and cooling, but the current warming trend we are seeing is proceeding at a rate that experts believe is unprecedented in the past 1,300 years. **And almost 97 percent of climate scientists agree that it's our fault (anthropogenic - human caused).**

For the last 800,000 years CO_2 levels have never been above 300 parts per million (ppm) and when CO_2 rose the average temperature of the planet went up. This data is

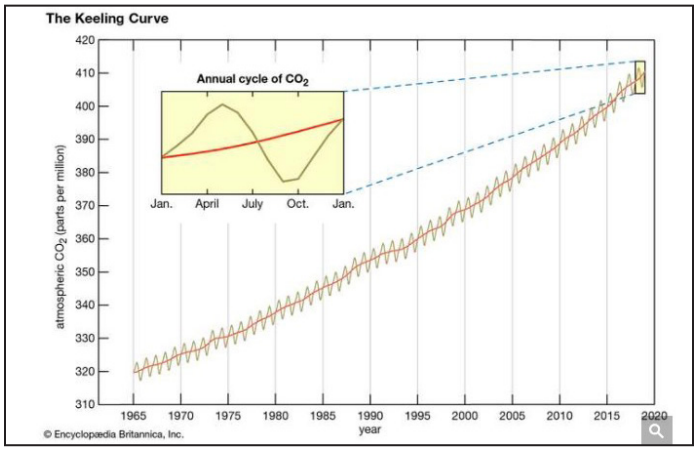


Chart provided by Morris Hills Environmental Action Club
Source: © Encyclopedia Britannica

continued on page 13

continued from page 12

TOO MANY BLANKETS! How Greenhouse Gases Are Overheating Our Planet

taken from ice cores in Antarctica where scientists are able to reconstruct the temperature vs. CO_2 level correlation. Low CO_2 levels in the atmosphere lead to low temperatures on Earth. Now our level of CO_2 is over 400 ppm and rising.

The process of greenhouse gases (most notably carbon dioxide) to regulate the temperature of our planet is a natural process that we call the greenhouse effect. Humans have increased the levels of carbon dioxide, methane, nitrous oxide, and halocarbons in the atmosphere, which has caused the average temperature of the Earth to rise above these normal levels.

Greenhouse gases (GHG) in our planet's atmosphere radiate energy in all directions. Part of this radiation is directed back towards the surface, warming the Earth. The intensity of the downward radiation – that is, the strength of the greenhouse effect – will depend on the atmosphere's temperature and on the amount of greenhouse gases that the atmosphere contains.

Think of this build-up of greenhouse gases like our planet putting on extra blankets: if we sleep without a blanket, heat escapes our body, and we feel cold. But if we have too many blankets, too much heat gets trapped, and we start to sweat. Greenhouse gases have always been critical in keeping our planet toasty enough to support life, however, human activity (mainly burning fossil fuels and deforestation) has pumped way too much into our atmosphere, causing global warming.

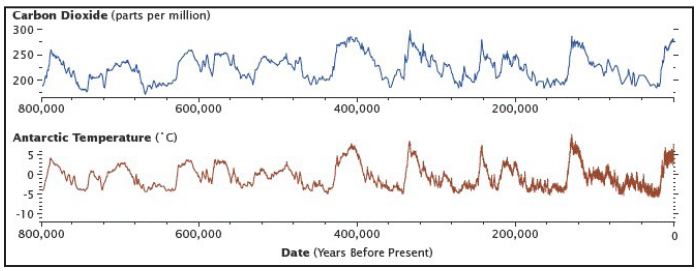
Here are some major culprits of this greenhouse effect:

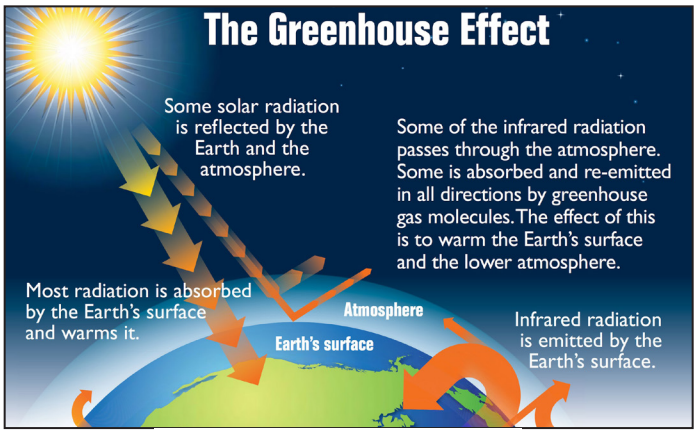
Carbon Dioxide

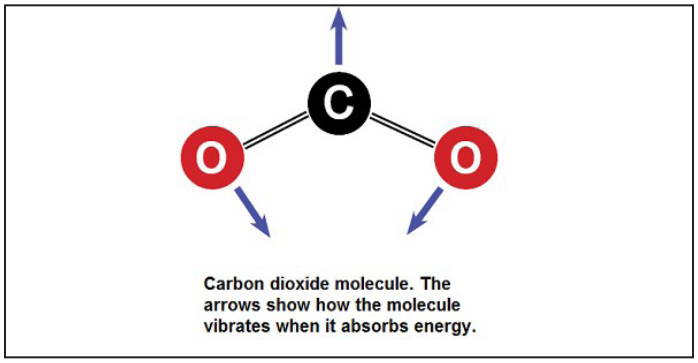
Carbon dioxide (CO_2) does a great job of trapping heat in our atmosphere, preventing Earth from becoming a ball of ice. However, scientists have found that CO_2 levels have unnaturally increased by 130 parts per million volume (ppmv) since the beginning of the Industrial Revolution in the mid 19th century. They are also expected to double within the next century.

CO_2 contributes to the greenhouse gas effect by being able to resonate with infrared (heat) radiation (while water molecules are able to absorb infrared radiation and hold on to that energy more effectively) that is trying to escape the Earth's atmosphere into space. This occurs when a molecule's resonance frequency is the same as that of the wave, this is true of all greenhouse gases. Once infrared (long wave radiation) is absorbed by the CO_2, it can either remain in Earth's atmosphere, transfer to another greenhouse gas molecule, or continue to escape into space.

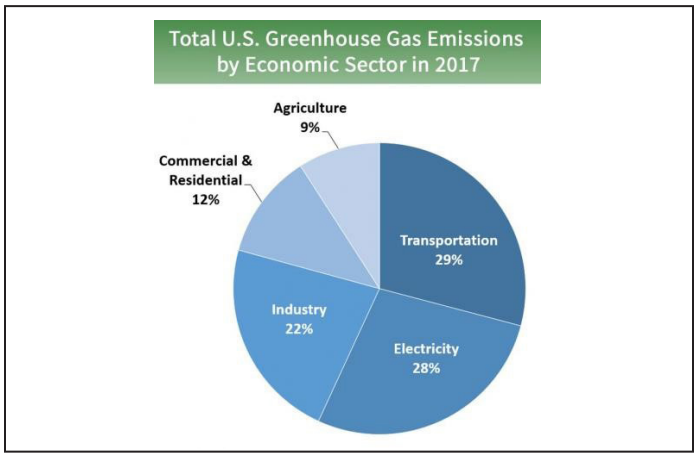
Human activity is largely responsible for the recent increase in CO_2 emissions as well as the destruction of many significant natural sinks. The majority of CO_2 emissions are







Carbon dioxide molecule. The arrows show how the molecule vibrates when it absorbs energy.



Charts provided by Morris Hills Environmental Action Club

***UPPER**: Source: NASA Earth Observatory*
***UPPER CENTER**: Source: US EPA*
***LOWER CENTER:** Source: National Oceanic & Atmospheric Admin (NOAA)*
***LOWER:** Source: Environmental Protection Agency (EPA)*

continued on page 14

continued from page 13

TOO MANY BLANKETS! How Greenhouse Gases Are Overheating Our Planet

Provided by Morris Hills Environmental Action Club / Source: Agricultural Research Service
About a quarter of methane emissions come straight out of livestock, most of it from belching! Each cow on a pasture can emit about 350 liters (92 gallons) of methane per day.

the result of burning fossil fuels. As of 2017 in our country, 29% of emissions are contributed from transportation and the need for gas and diesel; it is closely followed by electricity, which is responsible for 28% and industry at 22%. Finally, residential and commercial make up 12% with the remaining 9% being from agricultural sources.

In addition to producing excess amounts of CO_2 to begin with, humans are rapidly wiping out the forests that would most effectively remove that same excess CO_2 from the atmosphere. Motives behind deforestation and logging include using the land for cattle ranching, oil extraction, agriculture, and mining. Furthermore, oil extraction and coal mining only contribute to CO_2 emissions as both petroleum and coal emit large quantities of CO_2 when burned for fuel. This creates a cycle that accelerates the greenhouse effect at alarming rates.

Methane

Another potent factor in the phenomenon of global warming is methane (CH4), a gas that accounted for about 10.2 percent of all greenhouse gas emissions in the United States by human activity in 2017. It is a colorless, odorless, and highly flammable gas found in the troposphere that is used around the world to generate power and heat homes. The sources of methane in the natural world include things like volcanoes, undersea vents, and bacteria in the soil, but **more than 70% of the methane we have on the planet today comes from human activity.** Currently, natural gas and oil factories, along with power plants, are the most significant sources of methane emissions in the United States.

The main problem that methane causes is that it does the same thing as carbon dioxide, but it's far more devastating. When it comes to the power to absorb heat from the sun, methane is 84 times more effective at heating up the planet than CO_2.

In the past, this would be balanced by the fact that methane wasn't being released that often from natural sources (most volcanoes aren't erupting constantly); Today however, human activity has tipped the scales and made methane a major player in the changing climate of the planet. Methane is put into the air by humans in two major ways: through **leaks in natural gas pipes and emissions from livestock**, which can be explained by the graphic in *Figure 3*. The change has been drastic, with methane levels in the atmosphere being more than double what they were in the preindustrial era. With the pace of development in the world today, that level is only going to rise if no action is taken.

Nitrous Oxide

The Global Warming Potential (GWP) of a greenhouse gas measures how effective that gas is in warming the earth. Since it is being used as a basic point of reference, CO_2 has a GWP of 1, meaning a gas with a GWP of *n* is *n* times more effective towards warming the atmosphere than CO_2. Nitrous oxide (N_2O), a greenhouse gas that is often overlooked, only compensates for approximately 5.6% of greenhouse gas emissions caused by humanity. However, its GWP ranges from anywhere between 265-298, making it the second most destructive of the greenhouse gases, right below the halocarbons.

In addition, N_2O molecules remain in the atmosphere for 114 years before dissipating. Only 40% of N_2O emissions are a result of human activities, but due to N_2O's extended lifetime, its impact should not be ignored.

Halocarbons

One of the most recognizable pollutants behind carbon

continued on page 15

continued from page 14

TOO MANY BLANKETS! How Greenhouse Gases Are Overheating Our Planet

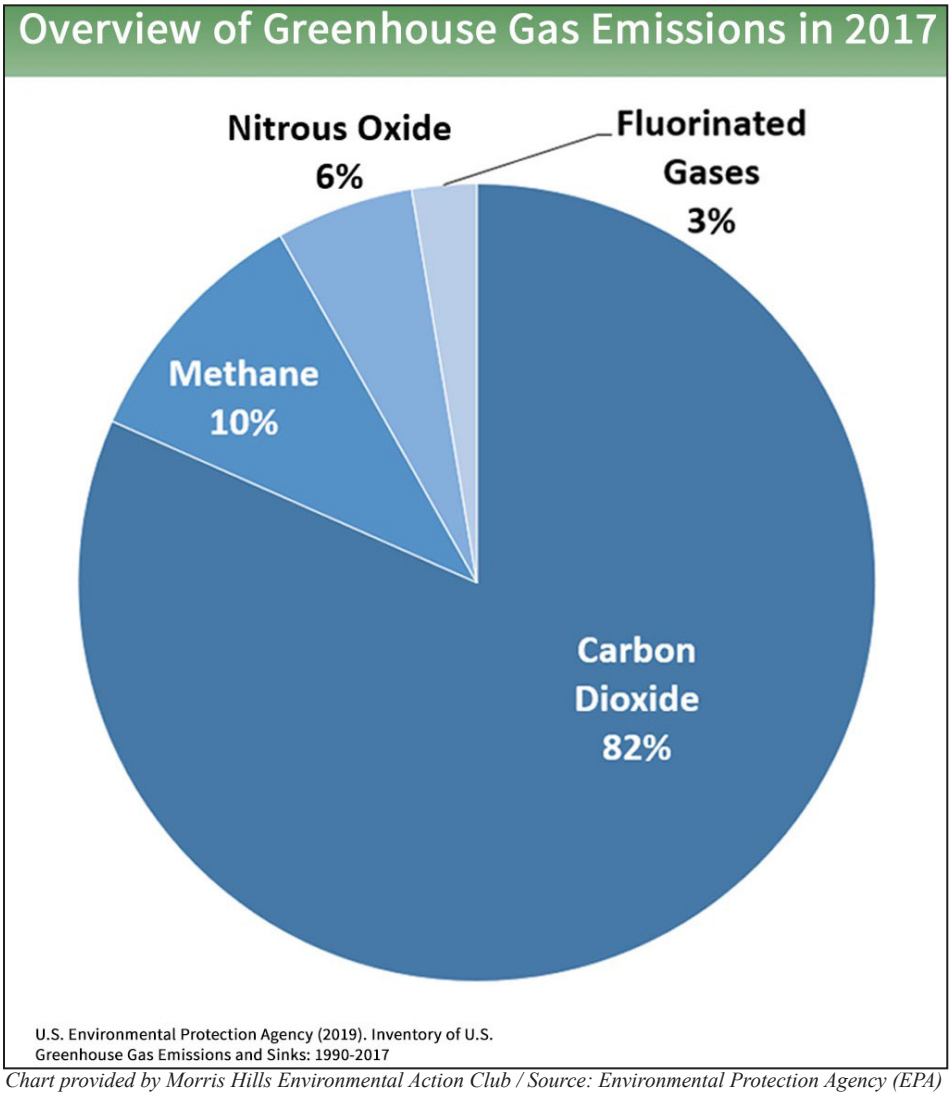


Chart provided by Morris Hills Environmental Action Club / Source: Environmental Protection Agency (EPA)

dioxide and methane is the **infamous killer of atmospheric ozone, chlorofluorocarbons (CFCs).** Inventor Thomas Midgley came up with two ideas: putting lead (tetraethyllead) into engines to increase octane and worked on a team to come up with a new refrigerant (Freon) with the chemical name chlorofluorocarbon. Time magazine later called these two inventions on their list of the 50 worst inventions. Midgley contracted lead poisoning and now CFC's have been largely replaced with other refrigerants, due to the 1987 treaty to limit ozone depleting chemicals (ozone depletion is a separate issue from climate change although the CFC's are harmful to both issues).

Not only do CFCs and other halocarbons wreak havoc on the atmospheric ozone which shields the Earth from harmful UV (ultraviolet) radiation, but they also are thousands of times more effective than carbon dioxide for trapping heat in the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) rates halocarbons as all being of greater potential to affect the climate, with a majority being a magnitude of 1000 times greater or more, with some reaching as high as 11,000. With their destructive potential for both our climate and our ozone, the family of halocarbons deserves far more attention than they are currently afforded.

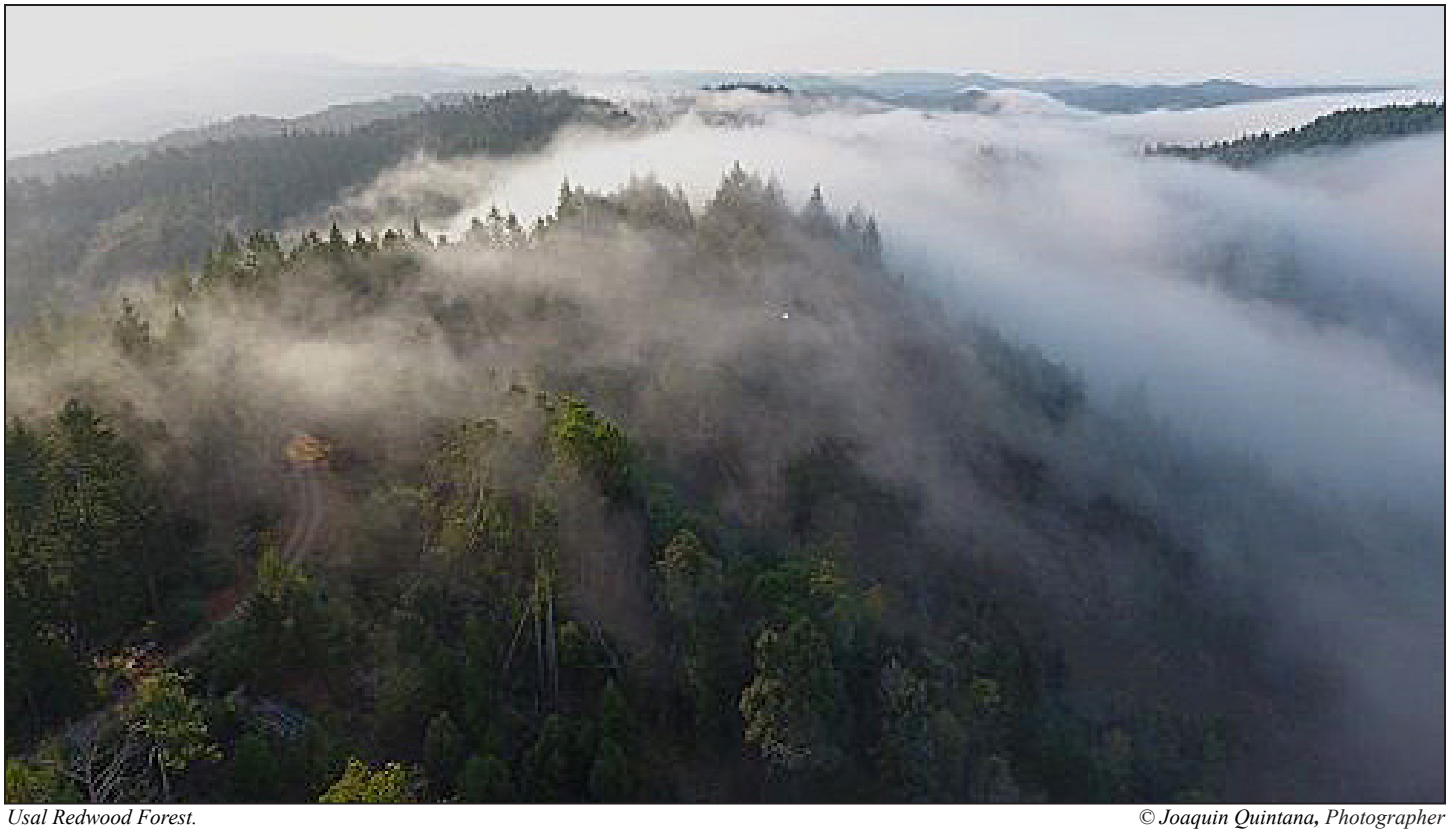
Water vapor

Methane and carbon dioxide gets all the attention as being one of the major greenhouse gases. **However, water vapor is the most abundant greenhouse gases on the planet,** being an extremely good absorber of infrared radiation (heat). As anyone who has heated up a pot of water on the stove knows that it takes a lot of energy to heat the water up.

If you take a walk on the Jersey shore on a hot summer day, the sand, road, and boardwalk will burn your bare feet. But the ocean will feel cool. That is because the water takes a lot of energy to heat up, while the sand and road reflect (give up) that heat to your bare feet. **So, we are fooled by the water vapor absorbing lots of heat, yet we do not feel it.**

Because of this property of water, our oceans are big absorbers of heat. It also is an effective absorber of CO_2. That is why we are not really feeling the effects of increasing CO_2 and heat: the oceans are diluting the impact by absorbing both. But we cannot keep counting on this; as the ocean are saturated with CO_2, the carbon causes it to warm and shake, eventually making it an *emitter* of CO_2. It is just like soda: If you shake the bottle, the dissolved CO_2 comes out of the drink. So a positive feedback loop is formed, where the more CO_2 the ocean absorbs, the more it warms it up, and the more it warms up, the more CO_2 is released to the atmosphere, warming the planet even more.

This is a vicious cycle that can only be stopped by cutting it at its source. If we can reduce the levels of greenhouse gases, we can end global warming and ensure the health of a planet we are entrusted to care for. **There is only so much time we have to change course before the irreversible happens.**



Usal Redwood Forest. *© Joaquin Quintana, Photographer*

REDWOOD FORESTS
CLIMATE CHAMPIONS

by Lin Morgan Barrett
Community Development Director, Redwood Forest Foundation

Although all trees pull carbon dioxide from the air and release oxygen, helping to stabilize the climate, old-growth redwood forests store more carbon above-ground per acre than any other forest on earth!

The loud, incessant hammering of the pileated woodpecker brought back memories of growing up in California's majestic redwoods. It was there, as a child, I first heard that hammering and was amazed to see "Woody Woodpecker" at work on a nearby snag. While most of the ancient giants were gone even then, the remaining goliaths of my childhood were enthralling.

The quiet in the redwoods, the world's tallest trees, is other-worldly. Winter then brought vast runs of steelhead and salmon that dwarfed the small riverbed they spawned in.

These beautiful redwood forests are climate champions! Although all trees pull carbon dioxide from the air and release oxygen, helping to stabilize the climate, *old-growth redwood forests store more carbon above-ground per acre than any other forest on earth.*

Coast redwood, Sequoia Sempervirens, occur naturally only on a narrow strip of land, stretching along the Pacific Ocean from Monterey, California to southwest Oregon.

Despite 150 years of aggressive over-harvesting, the remaining redwood forests still provide vital habitat for a variety of fish and wildlife. Old growth redwood treetops contain an array of canopy dwellers, some of whom never

Ancient Redwood misshapened by the wind. *© Eric Mulder, Photographer*

continued on page 17

continued from page 16

REDWOOD FORESTS CLIMATE CHAMPIONS

touch the ground. Redwood forests are home to mountain lions, black bear, Roosevelt elk, bald eagles, and my old friend the pileated woodpecker. Some species, however, are barely hanging on: Northern Spotted Owls, marbled murrelets, salmon, steelhead and various amphibians struggle to survive in logged-over stands.

Redwood giants, one of the world's fastest growing conifers, reach heights of more than 350 feet, and can live 2,000 years. Some redwoods are 24 feet wide and weigh 1.6 million pounds. Hyperion, the world's tallest tree, is a 379.7 ft. tall redwood. Redwoods have existed on this planet for more than 240 million years. As their name suggests, coast redwoods need a moderate, coastal climate to survive. The region's frequent fog is crucial. Like the Sequoia Gigantea in the Sierras, redwoods have shallow root systems that require abundant water. Coast redwoods, however, typically get their water from rain and fog, not snowmelt. They get 30-40% of their moisture from fog. Their large root systems often extend 100 feet, intertwining with roots of other redwoods. Interestingly, a cut redwood can clone itself, and young redwoods often sprout from their parents' base, drawing nutrients from their roots.

Only five percent of the ancient redwood forest remains. Redwood forests are magnificent; the wood they provide is an unequaled building product. It is durable, resistant to rot and termites, non-warping, and relatively soft. Beginning with the California Gold Rush and through the 20th century, redwoods were cut rapaciously to build homes and commercial buildings. A successful logging industry grew to meet building needs that, along with fishing, created prosperous rural areas. Over the 20th century, however, both resources dwindled severely, enraging environmentalists. By the 1980s, violent conflict between industrial and environmental interests rocked the redwood region. The *Timber Wars* saw neighbor pitted against neighbor; fights broke out at local youth soccer games. *Earth First!* and others, outraged at the assault on these magnificent forests and ecosystems, staged *Redwood Summer.* Deadly violence ensued. The scene was comparable to today's pipeline and fracking confrontations, conflicts that significantly impact local communities.

Fortunately, local leaders emerged recognizing that the resource was threatened, along with the economy, ecology and the social fabric of the region. Warring northern California coastal residents begrudgingly came together to seek non-violent solutions to protect and restore the forests, to provide jobs, and support local economies. A tall order!

In 1997, after nearly a decade of contentious meetings, the Redwood Forest Foundation, Inc. (RFFI) was born. Leaders of this remarkable grassroots movement worked with warring factions, all neighbors and forest stakeholders, for almost a decade to find common ground. Art Harwood, a local mill owner and RFFI's first President, RFFI Founder, Henry Gundling, a financial advisor and forest owner, University of California science advisors Pete Passof and Greg Giusti, portable mill operator, Bill Heil, and environmental leaders, Linda Perkins and Meca Wawona, moved into the forefront of the highly contentious conversation. Others joined, and over time loggers, foresters, scientists, environmental activists, financiers, and residents carefully crafted an agreement to establish a nonprofit organization to: *acquire, protect, restore, and manage forestlands and other related resources in the Redwood Region for the long-term benefit of the communities located there.* They sought to establish local control over the protection, restoration and use

© Photograph of Painting by Judith Hope Old Growth Redwood.

of natural resources, principally the coast redwood ecosystem. They wanted to ensure local ownership, eschewing the loss of local control that accompanies absentee industry or government ownership. The ultimate goal was to establish working community forests managed sustainably to protect and restore the ecosystem, provide wood products,

continued on page 18

continued from page 17

REDWOOD FORESTS CLIMATE CHAMPIONS

© ***LEFT:*** *Photograph provided by www.rffi.org* ***RIGHT****: Mark Welther, Photographer*

LEFT: *RFFI's Joaquin Quintana assessing road damage from epic winter storm..* ***RIGHT:*** *RFFI Community Redwood Planting in Redwood Regional Park.*

support the local economy and eventually invest any excess revenue into the community.

The founders engaged Tom Tuchmann, President US Forest Capital, to help them craft a sophisticated market-based strategy that would use private capital to leverage public and philanthropic dollars to acquire, restore and retain control of local forests. The strategy also required "monetizing ecosystem services." This is fancy jargon for creating funding for 'services' a forest provides: e.g., clean water, clean air, carbon storage, fish and wildlife habitat and recreation. They met with policy makers to help shape policies that would bring these ideas to fruition.

One successful policy change was the creation of California's carbon credit program. In 2006, the State of California enacted AB32, the "Global Warming Solutions Act." This law empowered the California Air Resources Board to create a market-driven system to reduce California's carbon dioxide emissions, an act that led to the state's pioneering, cap-and-trade climate action program. AB 32's goal was to reduce carbon emissions in CA to the 1990-level by the year 2020. In 2017, AB32 was extended to 2030 with a mandate to reduce carbon emissions an additional 40% below 1990-levels by 2030.

In 2007, RFFI purchased the Usal Redwood Forest in northern California. With an environmental loan from the Bank of America, they now owned and sustainably manage a 50,000-acre forest that is almost twice the size of the city of San Francisco, establishing the largest working community forest in California, and perhaps the nation. In 2020, RFFI is now embarking on a second forest purchase, the Reist Ranch. (rffi.org/ReistRanch).

From the outset, Bank of America cast this loan as an investment aimed at addressing climate change. RFFI protected the land with a conservation easement, assuring it will remain an unfragmented, sustainably managed forest in perpetuity. RFFI helped secure funding from the California Coastal Conservancy to preserve an ocean-front 1,000-acre parcel containing old-growth redwoods-then part of Usal. This transaction protected these ancient trees forever. The conservation easement sale, funded by the California Wildlife Conservation Board, and the preservation sale of 1,000-acres of ancient redwoods, were used to pay-down the debt - examples of using private capital to leverage public and philanthropic dollars to protect forests.

During the past decade, under the leadership of President Mark Welther, RFFI has improved the ecology and economy, while supporting social equity in the redwood region. Our work simultaneously addresses climate disruption, forest resilience, drought and prevention of catastrophic forest fires. RFFI owns the Usal Forest through its subsidiary, Usal Redwood Forest Company (URFC), led by Chief Forester Linwood Gill. We have completed $5,000,000 of forest and watershed restoration in two major watersheds, including northern California's most significant salmon-bearing streams. Since 2007, we have removed silt-producing roads, improved salmon habitat,

© ***Mitzi Rider****, Photographer*

RFFI's Usal Redwood Forest forestry staff; l-r: Karen Youngblood, Linwood Gill, Travis Munoz, Joaquin Quintana, absent Jeff Houser.

continued on page 19

continued from page 18

REDWOOD FORESTS CLIMATE CHAMPIONS

LEFT: *Biochar machine.* ***RIGHT:*** *Barrels of Biochar.*

© Raymond Baltar, Photographer, FFI Biochar Project Manager.

and salmon have returned. Our redwood reforestation program, including Plant-a-Redwood-Now, has planted more than 135,000 redwoods. URFC annually contributes over $3.5 million to the local economy, has created 170 living-wage jobs, has conducted four years of sustainable timber production, and is in full compliance with our loan. Overall, RFFI's carbon project remains California's largest forest carbon sequestration project, having sequestered more than five million metric tonnes of carbon. Our forest management is FSC® C124496 certified, and adheres to California Department of Forestry regulations. Our work is governed by local residents, steeped in forestry, finance, science and social entrepreneurship. An actively engaged community advises forest management.

Additionally, we developed a climate-friendly method of eliminating competing species that choke out the conifers, by pioneering forest-based biochar production. RFFI removes competing brush and hardwoods and converts them to North Coast Biochar, using a process called pyrolysis. Biochar is then used by farmers as a carbon-rich soil amendment. It heals the earth by holding nutrients and water in the soil, and stores carbon for hundreds, perhaps thousands of years. This synergistic project, "Forest to Farm and Beyond," supports forest resilience, reduces the danger of catastrophic forest fires, reduces agricultural water use and provides significant benefits to soil and the climate.

The Intergovernmental Panel on Climate Change (IPCC), commissioned by the United Nations, has provided objective, scientific information about the risk of human-induced climate change, and its natural, political, and economic impacts, as well as possible solutions. The IPCC's Fifth Assessment Report provided critical scientific input into the 2015 Paris Agreement. They have quantified the consequent natural, political, and economic impacts and risks. The IPCC and other scientists tell us we have 8-10 years to implement climate change solutions or the world will reach irreversible tipping points after which life on earth will become increasingly unbearable. Scientists have identified the most powerful natural climate solutions, along with the required life-style and technological changes. Natural solutions are not the complete answer, but they sequester carbon while we transition from reliance on fossil fuels and develop new technologies that draw carbon out of the atmosphere. Natural solutions can buy time as we make important life-style changes and implement other solutions.

Our pioneering climate action landed RFFI a significant role in *Ice on Fire*, the science-based Leonardo DiCaprio HBO climate disruption documentary. The film premiered at the Cannes Film Festival in May 2019, and has since generated global interest and support. Our sustainable forest management, tree-planting project, major forest landscape conservation and restoration, Usal Forest Carbon Project, along with our biochar project, catapulted

© Photograph provided by www.rffi.org

Mark Welther, RFFI President and CEO, being interviewed for "Ice on Fire", DiCaprio HBO climate disruption documentary.

continued on page 20

continued from page 19

REDWOOD FORESTS CLIMATE CHAMPIONS

RFFI onto the world stage. RFFI's demonstrated ability to transcend regional conflict and carve out a new inclusive approach - providing community control over the use of forest resources - is considered a global model for natural solutions to climate change. It is an example of 'Project Drawdown' founder Paul Hawken's description of Real Change. "*Real change occurs from the bottom up; it occurs person to person, and it almost always occurs in small groups and locales and then bubbles up and aggregates to larger vectors of change*."

Ice on Fire Director Leila Conners and Producer Mathew Schmidt chose RFFI for the film because we are successfully employing three of the five most effective natural solutions to climate disruption:

1. Tree planting;
2. Sustainable forest conservation and management;
3. Sustainable agricultural practices, e.g., converting forest waste to biochar and placing it in the soil.

RFFI continues to work with Conners and Schmidt through Tree Media, on "Catching Carbon," a program using natural solutions and Direct Air Capture, a process that draws carbon from the air and stores it deep within the earth. Catching Carbon is a prototypical approach that uses Earth's major systems - oceans, forests, soil - to heal the planet while implementing promising new climate technology.

If you want to address climate change, we suggest you *Start With Forests!* Protect, conserve, restore, reforest and sustainably manage existing forests. Plant trees! Mature forests and tree planting have powerful carbon sequestration capacity, as do kelp beds and tidal pools. Together, these can serve as primary methods of sequestering carbon over the next eight to ten years that are critical to avoid reaching irreversible climate tipping points. *Proceedings of the National Academy of Sciences*, reports that nature-based solutions can provide up to 37% of the emission reductions needed by 2030 to keep global temperature increases under 2° C.

The Redwood Forest Foundation has been featured in Ice on Fire, and honored by other organizations for pioneering climate action. While sustainable management of redwood forests holds special climate benefits because of the species' powerful carbon sequestration capacity, the RFFI Model is applicable to forests of all types. We receive requests from around the world for guidance and consultation.

There is a growing awareness and desire to replicate the RFFI model because it is uniquely designed to provide an immediate, inclusive, thoughtful, scientific, and market-based response to the greatest crisis the civilized world has ever faced.

TOP *© Photograph provided by Tree Media*
BOTTOM: *© Photograph provided by www.rffi.org*

TOP: *South Fork Eel River-a major salmon-bearing river.*
BOTTOM: *RFFI cleared streams of huge log jams, creating fish-friendly conditions in this tributary. Salmon are returning after 20 years!*

ABOUT THE REDWOOD FOREST FOUNDATION

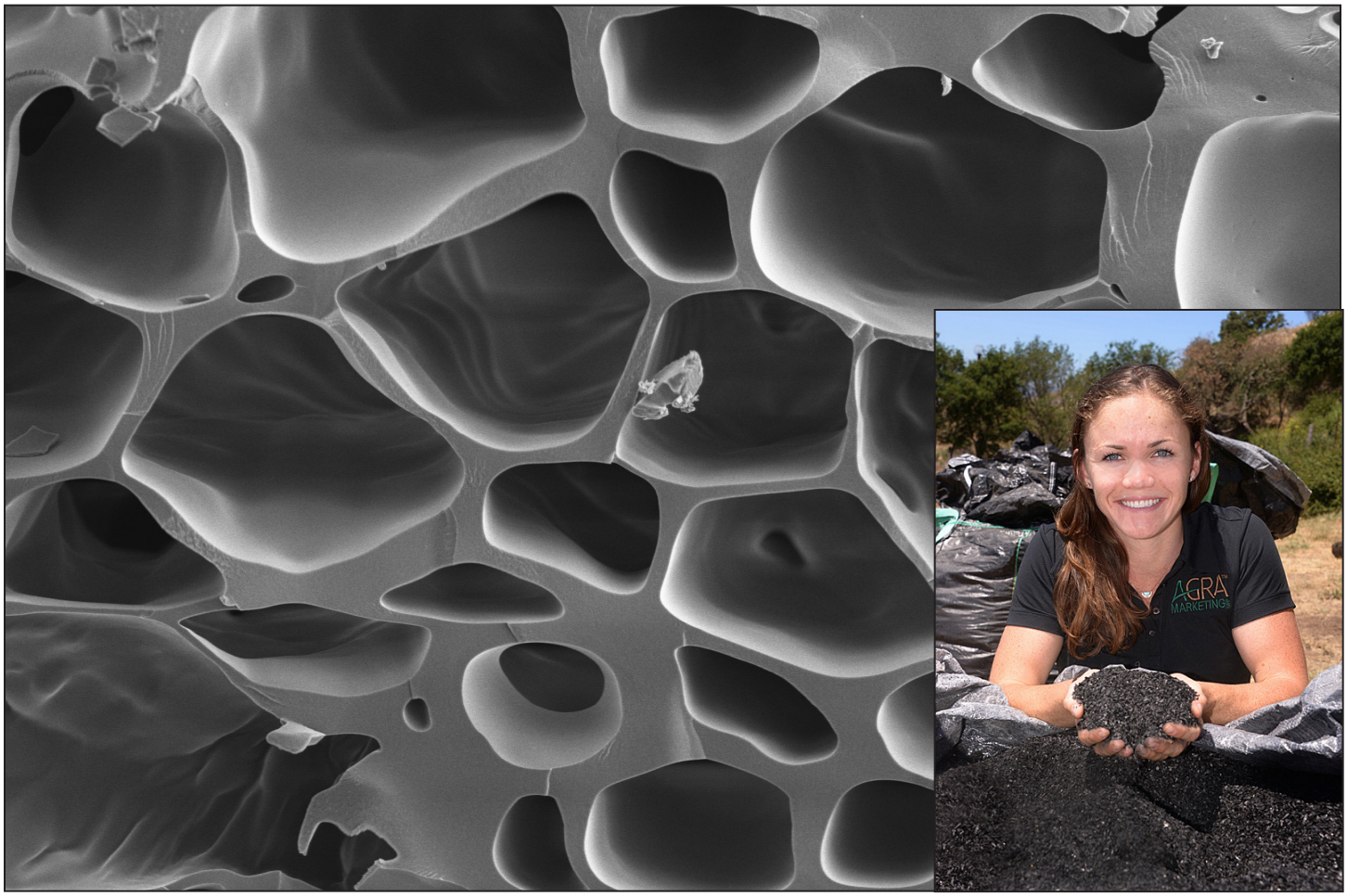
The Redwood Forest Foundation, Inc. (RFFI), a 501(c)(3) non-profit, is a grass-roots organization. We are loggers, environmentalists, mill-owners, community activists, foresters, economists, financiers and others all working together to establish community- based forests that provide both critical habitat for increased biodiversity and improved regional economic vitality.

Our mission is to acquire, protect, restore, and manage forestlands and other related resources in the Redwood Region for the long-term benefit of its regional communities.

More information about RFFI: www.rffi.org

Contact Lin Morgan Barrett at: morgan@rffi.org

Scientific Reference Sources Available at: https://www.rffi.org/climate-action/



ABOVE: *© Dr. Jocelyn, Photographer* ***INSERT:*** *© Raymond Baltar, Photographer*

ABOVE: *A microscopic photograph of biochar showing its porous structure.*
INSERT: *Maddie from Agra Marketing shows off biochar produced by Oregon Biochar Solutions.*

BIOCHAR: A CLIMATE MITIGATION STRATEGY

by Raymond Baltar, MBA
Director Sonoma Biochar Initiative and Biochar Projects Manager, Sonoma Ecology Center

and David Morell, PhD
Chair, Sonoma Ecology Center Board of Directors / ex-EPA official

The stunning movie *Ice on Fire* reinforces the powerful impact of a recent UN Intergovernmental Panel on Climate Change (IPCC) report / our planet faces catastrophic impacts within a very few years from society's excessive use of fossil fuels. Effective action immediately is imperative. Indeed, even a rapid shift to solar power, EVs and wind turbines, the core elements of any "carbon neutral" strategy (that is, reducing new carbon emissions), is not sufficient by itself. In addition, we need extensive action that is truly "carbon negative," pulling vast amounts of carbon out of the atmosphere and figuring out how to use it in safe, measurable, and beneficial ways.

IPCC compared the costs and storage potential of six methods of carbon dioxide removal that could be deployed at scale, either now or in the future, to assist mankind in limiting global warming to 1.5 degrees Celsius, the cutoff point above which scientists warn uncontrollable climate shifts threaten civilization and ecosystems as we know them. These include Direct Air Capture and Storage (DACCS), Bioenergy Capture and Storage (BECCS), Enhanced Weathering, Biochar Production and Use, Afforestation and Reforestation, and Soil Carbon Sequestration. While there are pros and cons with each of these approaches, including cost, known and unknown environmental impacts, and readiness for immediate implementation, the last three could

continued on page 22

continued from page 21

BIOCHAR: A CLIMATE MITIGATION STRATEGY

LEFT: *Biochar produced during wildfires is nature's way of kickstarting regrowth of trees and plants in forest ecosystems.* ***RIGHT:*** *Biochar production can replace the lop and scatter technique in some situations.*

LEFT / RIGHT: *© Raymond Baltar, Photographer*

be scaled up NOW if enough resources were made available and a "Carbon Conservation Corps" were established to educate the public and do the work. Afforestation and reforestation should absolutely be implemented in both urban and wildland areas, where appropriate, and funding found to scale these actions. But these long-term actions can take many years to achieve their results. We can make a critical and imperative impact quickly by managing our forests properly, preventing them from being clear cut in the first place for short-term profit and conversion to ranching and mono-cropping, and dramatically increasing funds for land trusts to purchase timber rights from landowners thereby keeping more forests intact as carbon sinks. Carbon markets already recognize this approach, paying landowners such as the Redwood Forest Foundation, Inc. for the carbon it is now sequestering in the Usal Redwood Forest in northern California.

Likewise, improving soil health and resiliency in farming through reduced chemical use, increased addition of organic matter such as compost, and encouraging and supporting alternate methods such as no-till, rotational grazing, and cover cropping are other critical, easily implemented approaches that are known to work now, though conversion to these techniques will also take time to achieve results.

All of this, and more, is needed. But applying biochar to soils represents an IMMEDIATE as well as long-term strategy for burying carbon underground and keeping it out of the atmosphere. In addition to its carbon sequestration value, biochar has been shown to have a multitude of benefits for farmers, especially when used in conjunction with compost and other amendments, such as reduced water and nutrient use, improved production of beneficial soil microbes, and frequently, improved plant yields.

What is Biochar?

Biochar is a form of elemental carbon made by heating woody materials or crop residues in the absence of oxygen (a process termed "pyrolysis"). It can also be made as a byproduct of the gasification process used to produce biomass energy. Plant materials are made up primarily of cellulose, hemi-cellulose, and lignin, and when they are heated to high temperatures a thermo-chemical reaction occurs whereby the cellulosic material gasifies and much of the lignin is converted to a carbonaceous material we call charcoal. If this charcoal meets certain criteria we call it biochar. Biochar is highly porous, with an incredibly high surface area, and is both absorptive and adsorptive. It is the perfect home for microorganisms.

The inherent physical and chemical properties of biochar make it highly advantageous to increase soil health. Biochar's literally millions of tiny pores and adsorptive qualities are ideally suited to retain water and nutrients near plants' roots, rather than having these vital substances leach away. Inherent chemical interactions from the biochar stimulate microrrhizal fungi growth and increase cation-exchange activity in the soil, further enhancing plant growth.

In some processes both the gases and the heat generated can be captured and used for renewable energy production. In others, bio-oil is produced as well that can be refined into a number of products, including biofuels for vehicles and aircraft. So biochar production provides a number of products that can be monetized in addition to the biochar itself. Ideally biochar production operations would be co-located in "ecoparks," where other businesses could use these byproducts. The biochar field is ripe for development by entrepreneurs wanting to help make an impact on climate

continued on page 23

continued from page 22

BIOCHAR: A CLIMATE MITIGATION STRATEGY

Phoenix Energy's Gasification/Biochar Plant in Merced, California. *© Raymond Baltar, Photographer*

change and food security while also getting rewarded financially.

As outlined in the recent book "Burn: Using Fire to Cool the Earth" by Albert Bates and Kathleen Draper, different forms of biochar (perhaps a better term might be biocarbon), can be produced from abundant surplus feedstocks. While not suitable for agriculture, it could help sequester C02 in other ways — some with potentially enormous climate impacts such as replacing a portion of the sand used in cement and concrete production. Biochar/Biocarbon is also showing promise as a filtration medium for stormwater, in pollution remediation applications, and as a way to reduce enteric methane release in cattle when used as a feed supplement.

Official standards for biochar are still under development, and there are differing views within the industry about what these standards should be. But organizations such as the International Biochar Initiative, the United States Biochar Initiative, and a number of organizations developing carbon credit protocols along with universities working on grant-funded projects are collaborating to help build a consensus on standards. In California, biochar must contain at least 60% carbon by law to be labeled as such. However, its other characteristics are likely just as important when determining its efficacy in certain soils and with certain plant types, and this type of research is currently underway worldwide.

Available scientific results demonstrate that biochar can remain in the soil for centuries and perhaps even millennia time scales — just where we want this carbon, away from the atmosphere. This has been confirmed by analyzing the highly fertile, ancient "Terra Preta" soils in the Amazon, and discovering that they contain large percentages of charcoal, between 30% and 40% in some samples. It is thought that these soils were created by indigenous peoples over centuries to improve the poor, leached soil conditions in the tropics and enable or enhance agricultural activities.

Developing a Sustainable Biochar Industry

We believe that biochar production and use can play a role in a responsible, safe, and impactful carbon drawdown strategy that can be deployed to address the climate disruption crisis. However, it is critical that this be done in a way that does not lead to increased destruction of the world's forests, that does not

A Conservation Burn pile, using vines from a local winery, can reduce smoke pollution and produce biochar. *© Raymond Baltar, Photographer*

continued on page 24

continued from page 23

BIOCHAR: A CLIMATE MITIGATION STRATEGY

adversely affect communities where production plants and harvesting activities are undertaken, and in a way that has a verifiably carbon-negative end result. For these reasons we believe that in a phased scaling strategy, ONLY surplus biomass sources should initially be used and that the technology or method used for biochar production should have the lowest possible emissions.

Some business models include farming fast-growing plants like miscanthus, bamboo, or even hemp as feedstock for biochar production, and there are arguably good reasons for this type of operation, including (perhaps) better consistency and quality control of the final product, a potentially smaller environmental impact than the use of forestry-related materials, and lower transportation costs and environmental impacts. But growing monocrops present a different set of environmental impacts and problems, and given the amount of surplus biomass that could be better managed, upscaling these materials into a value-added product like biochar, where practical, makes the most sense.

Millions of tons of “waste” forest biomass are generated in the United States annually, along with millions of tons of agricultural “waste” residues. Much of this material is not being used in ways that can provide valuable co-benefits. Thus there is an enormous opportunity to convert a large portion of this material into baseload renewable energy, biochar and compost in community-based processing facilities. These processes would help reduce catastrophic wildfire damage to our communities, reduce harmful air pollution from wildfires as well as from standard open pile burning, sequester carbon beneficially in farm, rangeland and forest soils, and create healthier soils. This must and can be done responsibly and with as little damage to local ecosystems as possible.

We understand that the range of options may be limited depending on location, local support resources, and access to power, water, and other balance of system requirements. With training, even low-tech methods like pit, flame-cap kiln, or conservation burning can be used to produce good quality biochar with relatively low emissions. While we do not support the use of these techniques for commercial biochar production, each can play a role in better forest and ag waste management activities when compared to standard open burning.

There are legitimate concerns, based on past experience, that some large biomass energy facilities have not been good neighbors, both from environmental justice and pollution perspectives. While scaling the nascent biochar/biocarbon economy we need to make sure that mistakes of the industrial revolution are not repeated; that care is taken to site facilities properly; and that air and water resources are rigorously protected. A different ethic is needed in the

TOP: *© Photo courtesy Pacific Biochar*
CENTER TOP & BOTTOM, BOTTOM: *© Raymond Baltar, Photographer*

TOP: *Biological Activation of Biochar. Biochar should always be blended with nutrients before application.*
CENTER TOP: *The ROI Carbonator 500 is designed to process 15 tons per hour of surplus forestry residues while also converting a portion of the material to biochar.*
CENTER BOTTOM: *Biochar blended with compost is applied topically to a sheep pasture at Swallow Valley Farm in Sonoma County, California.*
BOTTOM: *A Comptech Crambo biomass shredder processes logs into material suitable for use in a pyrolysis machine called an Adam-Retort.*

continued on page 25

continued from page 24

BIOCHAR: A CLIMATE MITIGATION STRATEGY

business of forest materials management. While large plants typically source from otherwise unmerchantable "waste" streams, the amount of feedstock needed to keep these large plants in service 24/7, 365 can put pressure on operators to purchase materials from unsustainable or rogue logging operations when other sources are interrupted or are no longer available, especially in the developing world.

We therefore recommend "right-sizing" all biochar production facilities based on the long-term, sustainable flow of feedstock in each community Aa s w e l l a s on production efficiencies, and co-locating these plants wherever possible with other businesses that could use all of the systemic outputs—including greenhouses that could potentially use any C02 emissions and process heat.

This might mean a 500 KW biomass power and biochar plant located at a local co-packing facility in a farming community, or a 3 MW plant located at a composting operation closer to a city with a constant flow of urban wood "waste." A system of smaller biomass plants, capable of supplying baseload or peak power needs would also add to the resiliency of the power grid, especially during emergencies.

With oil and gas extraction we have been pulling fossil carbon out of the ground, often with great harm to the environment, and burning it, wreaking havoc on our weather system that is already threatening human and other ecosystems all over the planet. We need to need reverse this process, and if done right, scaling biochar production could begin to pull gigatons of carbon out of the short-term carbon cycle IMMEDIATELY, using only materials that are otherwise improperly utilized and existing and proven technology. In addition, integrating biochar into farming activities offers a "direct deposit" of valuable soil carbon that, when blended with natural materials like compost, could regenerate millions of acres of depleted soils and make good soils more resilient.

While there is much still to learn about biochar use, and production technologies need continual improvements, we strongly believe there is enough evidence that this simple, ancient act of charring biomass and using it to grow healthier soils, if done sustainably and with environmental safeguards, would, both now and into the future, help us address climate change and food security.

While much research still needs to be done to quantify and better understand which types of biochar have carbon that persists best in soils, data show that the time has come to start returning right away as much carbon as we can back into badly depleted soils throughout the farming community, and back into forest ecosystems as well. ***This can easily be done using biochar, providing a model for others to emulate elsewhere. Let's do this now!***

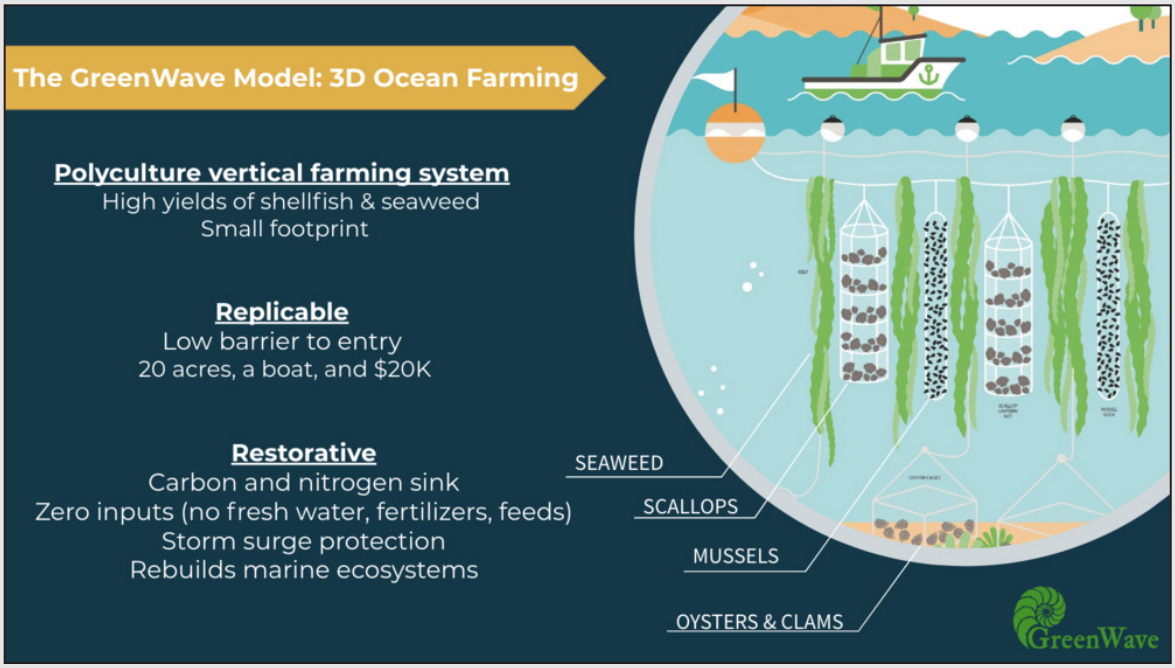
TOP: *Loren Poncia of Stemple Creek Ranch, Carbon Farmer.*
BOTTOM: *Biochar produced from tanoak by the Redwood Forest Foundation in northern California.*

About The Sonoma Ecology Center

The Sonoma Valley is home to an amazing variety of species living in a small space. As many as a quarter of California's species exist in this compact area, a place that comprises only a tenth of 1% of California's entire land area!

The Sonoma Ecology Center is a non-profit organization with a mission is to work with the community to identify and lead actions that achieve and sustain ecological health in the Sonoma Valley. Since the Valley is mostly privately owned over thousands of parcels, it works to address challenges related to water supply and quality, open space, rural character, biodiversity, energy, climate change, and a better quality of life for all residents.

For more information:
https://sonomaecologycenter.org/



GREENWAVE / Working Toward a Whole New Plant Based Ocean Industry

"***GreenWave*** *is a non-profit organization founded in 2014 dedicated to climate resilience and equity.*

We work in two areas: farm replication and market innovation. Our goal is a blue green economy - built and led by restorative ocean farmers - that feeds local communities while protecting the planet.

Land-based food production is in crisis - driven by climate change & population increase. We have to grow 70% more food by 2050 to accommodate 2 billion more people on the planet (World Bank 2017). While we try to feed more people, land-based farm yields will continue to drop with climate change and land degradation and will be insufficient for necessary production. Land-based agriculture contributes 24% of global greenhouse gas emissions - more than transportation (11%) and just as much as burning fossil fuels (25%). Wild fisheries cannot bear the burden: fish stocks are either fully fished or overfished.

GreenWave's polyculture vertical farming system grows a mix of seaweeds and shellfish that require zero inputs - making it the most sustainable form of food production on the planet - while sequestering carbon and rebuilding reef ecosystems. Since our farms sit below the surface and leverage the entire water column, they produce high yields with a small footprint. Our crops are used as food, fertilizer, animal feed and more. And, our farms are open source: anyone with 20 acres, a boat, and $20K can be up and running within one year. Our goal: 500 farms, 10 regions, 5 years.

Benefits of ocean farming include being:

Restorative & Regenerative

- *Zero inputs (no fresh water, fertilizer, feed, land)*
- *Sequesters Carbon and Nitrogen*
- *Provides storm surge protection*
- *Rebuilds marine ecosystems*
- *Cattle feed that contains 1% seaweed reduced methane output by 58%.*

Replicable

Each Reef has 25 to 50 small-scale ocean farms, a land-based hatchery and processing hub, and a ring of large-scale institutional buyers & entrepreneurs developing value-added products. These Reefs are then replicated up and down coastlines.

Scalable Impact

The World Bank estimates farming 5% of US waters could create 50 million new jobs; absorb 10 million tons of nitrogen and 135 million tons of carbon, and produce the equivalent protein of 3 trillion cheeseburgers. Thousands of plants grow in the ocean - this is just the beginning of a whole new plant-based ocean industry.

Market Innovation Programs

Scales demand for our farmers' crops by incubating early-stage product development, mobilizing investment, and opening new market opportunities for farmers. Our crops are used as food, fertilizer, animal feed, and more.

To date, GreenWave has trained and supported over 50 farmers and entrepreneurs throughout New England, California, New York, the Pacific Northwest and Alaska. "

Resource and For More Information:
https://www.greenwave.org/

continued from page 2

DISCOVERING NATURE

© Kristin Bolcarovic, Photographer

"ARCADIA EARTH"

an amazing museum in NYC!

Did I mention that this museum was also FUN? As you walk through all of the rooms of the exhibit, you travel with a tablet that picks up symbols and launches text that reveals shocking statistics on pollution. To make the experience even more interesting, you can find sharks, fish, giant sea turtles, and other marine animals that are all caught through the Arcadia Earth app on your phone or tablet.

Your senses are truly awakened. In the room about meat production, moss covers the walls and enhances the feeling of being on a farm. When you scan your QR code for this room, it discusses how it takes 1,800 gallons of water to produce just one pound of meat. As you continue through the exhibit, the rooms get hotter to reflect our change in climate until you reach the underwater room. This room is a personal favorite and one in which I believe kids will probably have the most fun. Through the use of virtual reality masks, they get to travel underwater and see the damage that we have done thus far.

Upon exiting the museum, you travel down a walkway with mirrors along both sides. Each mirror has statements providing ways in which people can help. Before leaving you can either make your own pledge to make a change or (for some of the younger visitors) simply sign the wall.

This exhibit is not only a great way to shed light on climate change and sustainable alternatives, but it is absolutely inspiring! Children and adults alike will walk out of this exhibit asking how they can help and what they can do. They will know and understand that each person can make a difference, and the choices we make do matter!

DID YOU KNOW?

- *The entire facility is made from recycled and biodegradable materials, including the flooring.*
- *New York uses 44,000 plastic bags per minute.*
- *10% of all ticket sales is donated to the oceanic global.*

For More Information: https://www.arcadia.earth/

THE DELAWARE VALLEY EAGLE ALLIANCE

working towards the conservation of our wildlife and natural resources

The Delaware Valley Eagle Alliance is a 501 (C)(3) not-for-profit organization with a mission to increase awareness, understanding and promote conservation of our wildlife and the natural environment. We accomplish this through our publications, projects and programs.

We believe that raising awareness and understanding will change attitudes toward conservation and our natural resources.

John A. DiGiorgio, Chairman and President
Richard Crandall, Director and Vice President
Yoke B. DiGiorgio, Director and Treasurer
Debra Reimer, Secretary

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PROJECTS AND PROGRAMS

We are available to work closely with biologists and conservation groups to document ecological and wildlife research on sensitive and endangered wildlife and environmental issues. We collaborate with communities and other organizations to develop and organize wildlife and environmental educational and entertaining programs.

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