

APPOGEO SPATIAL

ELEVATING GLOBAL AWARENESS

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"That's mind blowing. We have never been able to map so many reefs with such little field data to that level of detail. And in such little time." -Dr. Chris Roelfsema, Remote Sensing Research Centre, School of Earth and Environmental Sciences at Brisbane's Queensland University, Australia

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"In the end, the choices we make determine how much resilience and sustainability – how much equality and justice – will emerge from the socio-economic systems we have built."

-Hans-Peter Plag, PhD, Mitigation and Adaptation Research Institute, Old Dominion University

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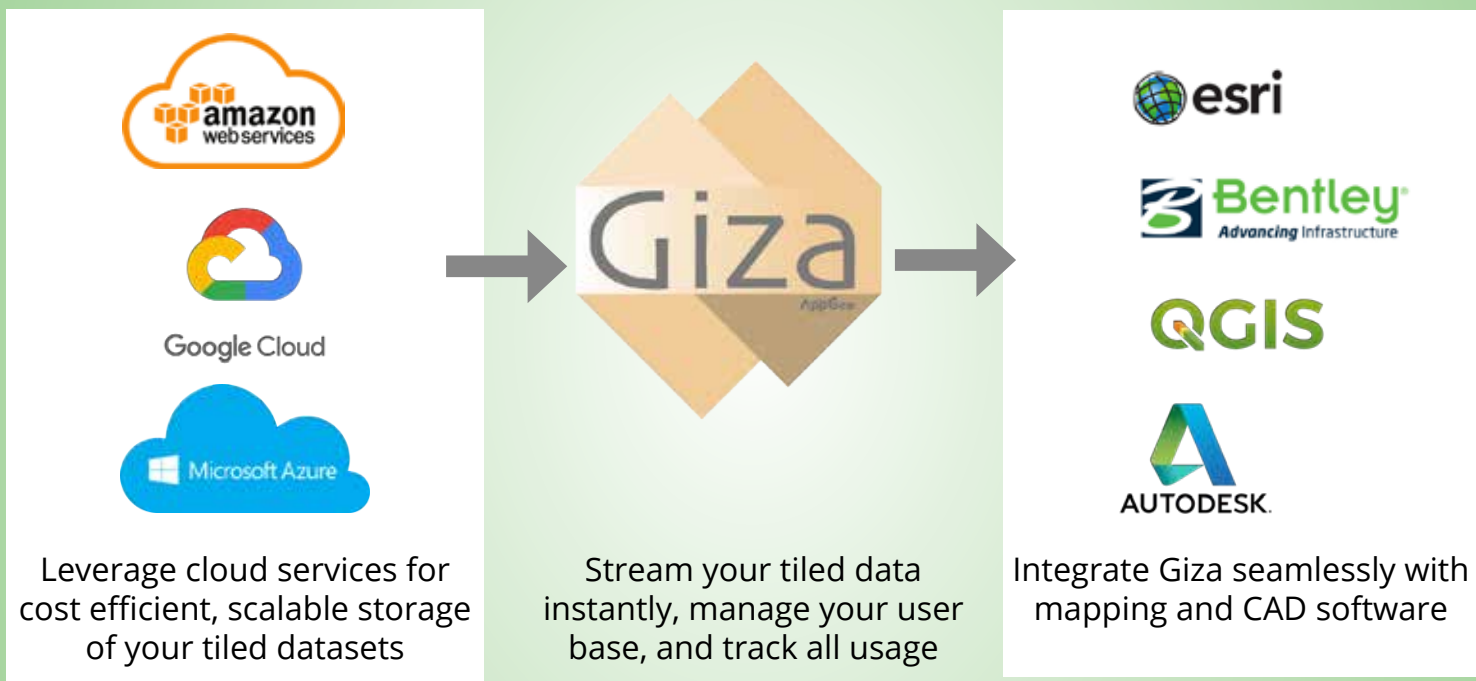
Image of the Great Barrier Reef off the east coast of Australia, courtesy of Maxar. See page 4 and 16 for more information.



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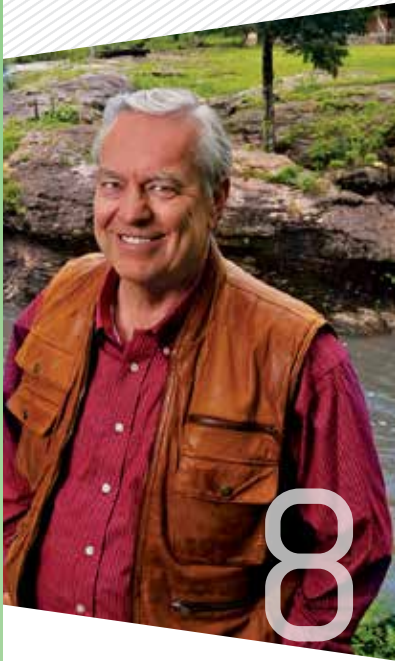


Georgia



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The Great Barrier Reef

The Great Barrier Reef is one of the world's most beloved natural wonders. Like many, it has succumbed to major degradation due to climate change. It's also incredibly large, stretching from an area the equivalent of from Vancouver, Canada to the southern tip of California. It includes 2,900 individual coral reefs, 600 islands, 300 coral cays, and 150 inshore mangrove islands that are home to thousands of different species. Also, of course, it's underwater, so it's been very difficult to map -- until now!

See page 16 to read about how this amazing part of our world is being mapped, and therefore, possibly, being saved.

APOGEO^o SPATIAL

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MISSION

Apogeo Spatial communicates the power of geospatial tools and technologies in managing the world's environment and scarce resources, so that the global population has the security of water, food, and energy.

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LETTER FROM THE PUBLISHER

Dear Readers,

The year 2020 will be one to remember. The current global situation is complicated. While it's extremely challenging for some, much good has come from it also.

This year is the 35th anniversary of *Apogeo Spatial*, and we are expanding our content and readership to include climate and space activists and enthusiasts who care about nature and biodiversity, while we will continue to cover uses of commercial remotely sensed data for projects that benefit the earth.

We are making some changes to the way we do business. First, we will finally be publishing articles ongoing online, rather than waiting until each new issue is released. This will provide fresher content, and allow us to be more timely with articles. We will still bring together groups of articles to create cohesive issues of the magazine as a pdf and in print. To add your email address to get monthly notifications, go to www.ApogeoSpatial.com/subscribe.

Second, we have hired the smart, talented and funny Melisa Harder (whom many of you know) as VP Marketing to create innovative sponsorship packages for you, so that you will get maximum impact from using *Apogeo Spatial* to deliver your marketing messages to our high-level audience of decision makers. She'll be in touch, and if you don't want to wait, just email melisa@apogeospacial.com.

In April, we celebrated the 50th anniversary of Earth Day by partnering with "Earth Matters," a series of one-minute videos about why earth matters by Bill Kurtis and John St. Augustine (page 8). You can see the first few episodes on our website: <http://apogeospacial.com/welcome-to-earth-matters/>.

The 20th Anniversary of the International Space Station is also this year. In our series on the ISS, we feature on page 22 views of ocean plastic as seen from space, and two youth activists who are cleaning up plastic from our waters. In these pivotal changing times, solutions like cleaning plastics from the ocean and mapping The Great Barrier Reef may not seem important. However, the long-term problems in the world still exist, and so we are sharing good news about solving them. The Great Barrier Reef is being mapped for the first time (page 16), thanks to Christopher Roelfsema, whom I met in 2010 at IGARSS, which I attended with Dr. Ray Williamson, our editor. I also met long-time columnist Hans-Peter Plag there, whose column "On the Edge" is on page 12 about what's needed for humanity at this time: resilience. This rings true on many levels. Dylan Taylor, founder/CEO of Voyager Space Holdings, shares wisdom about investing in space in "Spatial Capital" on page 10. I am grateful to all.

One year ago, I was in NYC celebrating the 50th Anniversary of NASA astronauts landing on the Moon at the NOVUS Summit with some amazing people at the United Nations HQ. The NOVUS Summit was a series of talks about people



Myrna James Yoo

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offering new Moonshots – audacious ideas to solve the UN-defined SDGs (Sustainable Development Goals). The community has been open and optimistic about the future, led by Kunal Sood.

My most recent talk planned for April at Geospatial World Forum in Amsterdam was cancelled. After 17 years of working in the space and satellite industry, and speaking at and attending almost a hundred conferences (most of which are not recorded), I have a broad unique view of the innovation and technical advancements. I am able to 'translate' the tech and reasons why people should care about this innovation, so that these important ideas are understood by more people. In case you missed it, my interview with David Mitlyng about Quantum Key Distribution is here, both written and as a podcast. I have been told that this helped people to understand the basics of quantum mechanics.

Read: <http://apogeospatial.com/quantum-key-distribution-in-space/>.

Listen: <http://apogeospatial.com/apogeo-spatial-podcast-with-david-mitlyng/>.

As we continue to cover tech and the ethics of pushing that envelope, watch for more interviews in the magazine about 3D Printing, Artificial Intelligence (AI), Machine Learning (ML), and the enabling technologies such as Internet of Things (IoT), quantum, blockchain and lasers (LiDAR, lasercomm). It's a very exciting time in our field! Contact me to be included in upcoming articles.

For the first time in publishing 75+ issues of this magazine, I'm including a personal essay (<http://apogeospatial.com/dispatches-from-the-field/>) about some pro bono work I've been doing with a very special nonprofit, Geoversity, located in Panama. We are taking their very solid 20-year foundation of learning from nature at their 12,500-acre Mamoni Valley Preserve, and of working with youth leaders from around the world, and founding the Geoversity School of Biocultural Leadership. This is such an absolutely critical time for the future of humanity, and we believe that evolving with nature is one of the most important elements needed. The new school is pulling together all of their expertise and curriculum under one blue sky roof, to attend to biodiversity and living systems, and to apply learning from biomimicry and immersion in the rainforest to businesses and leadership that is desperately needed to create a new future.

The venerable E.O. Wilson, ("The Father of Biodiversity," long-time Harvard professor), believes that we need to set aside 50% of the landmass as nature preserves to stop the loss of biodiversity. While 50% is a lofty goal, his point is well taken by the team in Panama.

Here also is the link to our feature about Geoversity's work and professional-level maps and data, "PanaMapping: GIS for Conservation Science," thanks to their partnership with The University of Redlands:

<http://apogeospatial.com/panamapping-gis-for-conservation-science/>.

The articles about Geoversity demonstrate how *Apogeo Spatial* has evolved in 17 years. It has always been about data from space to study the earth, for the sake of humanity. We care about the earth because humanity needs a place to live. I have always been a humanitarian at heart. And now, we are noticing how the health of humans is directly related to and dependent upon their connection to the earth as a sacred living system.

Not only is nature healing emotionally and spiritually, but the actual resonance of the earth's electromagnetic field can "recharge" our bodies into a more balanced state. The earth is gloriously and inherently tied to human health and vitality, and we find ourselves at this fascinating important nexus. We're so grateful you're along for the ride. Please share with your friends and colleagues who may want to join us.

Warmly,
Myrna

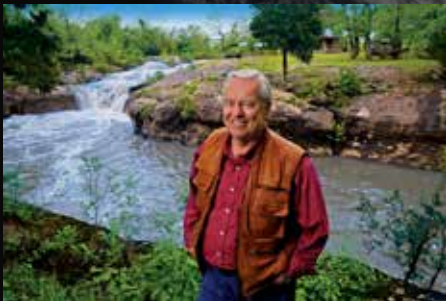
Welcome to Earth Matters

a Partner of

Λ P O G E O °
S P A T I A L

Watch the one-minute videos of Earth Matters to be entertained, informed and inspired

Joining forces with *Apogeo Spatial* is *Earth Matters*, a series of inspiring one-minute videos about the significance of planet Earth, the only home that humanity has ever known. The series offers informative videos about the earth, its living systems, its interconnectedness, and its miracles. The videos will appear with fresh content regularly on www.ApogeoSpatial.com.



Earth Matters made its debut as a radio show in 2013 with the highly respected journalist and A&E icon Bill Kurtis as the host. The intent

of the program is to present concise information in just one minute that leads to transformation, as listeners learn more about planet Earth and what role we all play in the unfolding future. John St. Augustine is the creator and

executive producer of the show that is taped at the award-winning Kurtis Productions in Chicago.

Celebrating the 50th Anniversary of Earth Day this year, John interviewed his friend Bill on his podcast, *Life 2.0*. The old friends remember the first Earth Day, when Bill was invited to Belmont Harbor in Chicago and found himself literally hugging trees, and some history, including a note about the creation of the EPA by Richard Nixon just a few months after Earth Day, and going back further to the beginning of measuring carbon by Charles David Keeling. Of course, now the chart measuring carbon increases is famously known as "The Keeling Curve" and "The Hockey Stick Graph" to which every climate activist refers, showing the spike in carbon levels in recent years. In 1999, Bill produced a movie called "Earth in the Hot Seat" after traveling the world for a year to film the effects of climate change. Ojibwe elder Muk-Ta-The' says that Kurtis "speaks for the Earth."

Photo credit: Earth by NASA, January 2012

In his Life 2.0 podcast for May 26, John interviews Myrna to announce this partnership, and to hear about her journey, and how she came to care so much about using data from space to study the Earth, ultimately for the benefit of humanity. They discuss the important connection among all living beings, from plants and animals to humans around the globe, and how it has been thwarted in so many ways. She is committed to creating ways for that tie to be reconnected, for life itself to be celebrated and honored, which is to the benefit of each human. In addition to sharing this in *Apogeo Spatial*, she also works with Geoversity, an ecosystem of leaders and organizations collaborating in the pursuit of breakthroughs in human design, enterprise, and creative



expression, inspired by nature in Panama. Read about that on page 26.

“The intent of *Earth Matters* has always been to inform and inspire individuals to

take concrete, constructive actions in creating a sustainable future. The 300-episode radio version of the project reached millions of people. This partnership with *Apogeo Spatial* offers video, and increases the depth, breadth and impact of those messages, and we are confident that our collaborative efforts will be of great significance in raising awareness when it comes to *Earth Matters*.”

-Bill Kurtis & John St. Augustine



Plastics in the ocean photos in Indonesia, courtesy of Make a Change World, Gary and Sam Benchehib, <https://makeachange.world>.

Life 2.0 Podcast Features Myrna James Yoo

To hear the interviews with Bill Kurtis and Myrna, and about how this partnership came about via synchronicities, listen to the April 22 and May 26 episodes of Life 2.0 with John St. Augustine, https://bit.ly/Podcast_Myrna.

Earth Matters: Plastic in the Oceans

(listen at www.ApogeoSpatial.com)

One of the greatest inventions, it seemed, was plastic, but more and more it has been showing up where it was never intended. From toothbrushes to toilet seats, from lunchboxes to milk bottles, plastic products have changed the way we live. However, like most ideas humans come up with, disposal of products after their use wasn't really thought out, and post-World War II, when we became a throw-away society, a massive amount of plastic has shown up where it was never intended to be: in the oceans of the world where fish and seabirds mistake the bits of plastic for food, disrupting the natural order.

It's estimated that there are 300,000 tons of plastic in the ocean that eventually leaches toxins into the water supply. Americans discard 33.6 million tons of plastic each year but only 6.5 million tons are recycled. If you are not sure that reducing, reusing and recycling has any effect, guess again.

Copyright: *Earth Matters*, Aurora Media, Kurtis Productions

Editor's Note:

The International Space Station currently carries instruments that can see plastic in the oceans from space. Read about that on page 22, including more about activist Gary Benchehib.



Dylan Taylor

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Founder

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Voyager Space Holdings is a privately held global holding company in the space exploration industry. Voyager seeks to increase vertical integration and mission capability to enable humanity's most ambitious projects.

Editor's Note: Dylan writes regularly for additional publications. Recently, he contributed the op-ed to Space News, "Envisioning the Next 50 Years in Space." <https://spacenews.com/op-ed-envisioning-the-next-50-years-in-space/>

The Four Horsemen of Space Finance

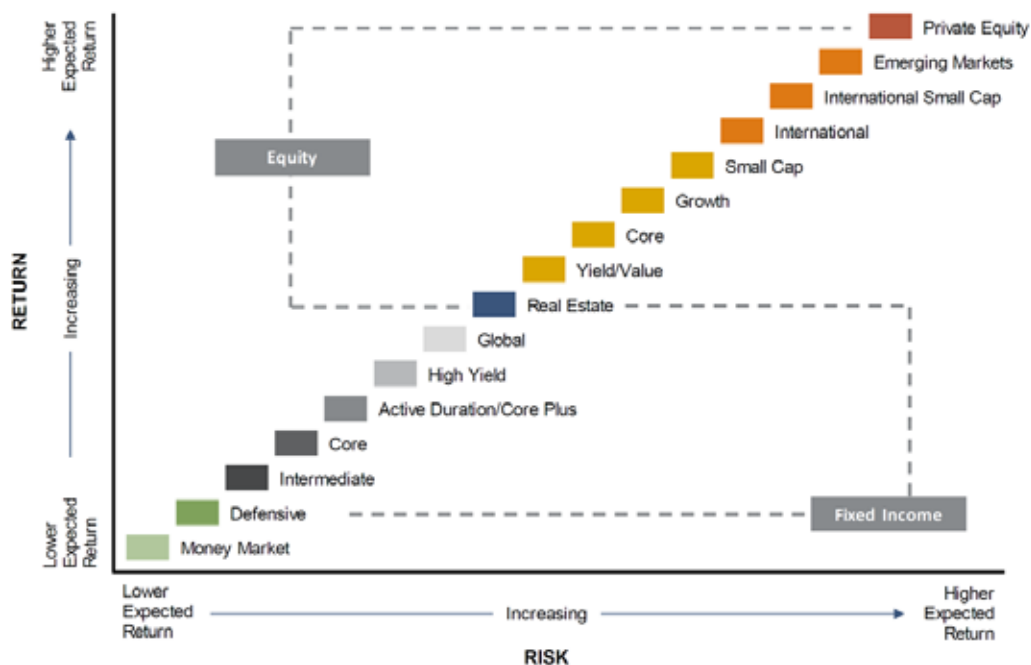
A GUIDE TO INVESTING IN THE SPACE INDUSTRY

THE SPACE INDUSTRY HAS COME A LONG WAY IN THE PAST TEN YEARS. Not only have key technologies such as launch reusability and 3D printing in space been demonstrated successfully, the nature of space finance has also evolved significantly. Ten years ago, the industry struggled to attract early-stage angel capital. With that problem now largely solved, venture capital firms and other institutional investors have entered the industry in a meaningful way. Despite this, space finance remains perhaps the biggest challenge to truly opening up the high frontier. This begs the question as to why space financing is so hard. Additionally, we can ask how is space different from other industries? And what can we as an industry do about it?

First Principle of Investments

To better understand space finance, it is best to start with the basics about any type of investment. In general, the governing principle is risk versus reward. As the chart below shows, for a higher level of risk, you would expect a higher return. This is why equities typically have higher returns than debt. Since debt holders are paid first, and equity holders get what is left over, the debt holders are in a superior (and less risky) position. For this lower level of risk, a lower return is required.

However, at the upper right of the chart, you can see some anomalies. For example, why would private equity (primarily a US-based invention) have a higher return than emerging markets, which are typically economies that have much more systemic risk? The answer is that while you can buy emerging markets in a mutual fund, you can't necessarily do that with private equity. Therefore, private equity is less liquid (e.g. you can't sell it at the push of a button on the open market). This lack of liquidity means that investors need a higher return in order to agree to this.



Source: Callan

The Four Horsemen of Space Finance

In the case of space, not only are the investments risky, they are usually illiquid. If that weren't bad enough, there are two additional negatives that typical space investments have that many other industries do not. They require high capital expenditures (CapEx) and have very long-term horizons for investment payback. Collectively, I call these four challenges (risk, illiquidity, high CapEx and long-term horizons) the Four Horsemen of Space Finance.

High capital expenditures, of course, mean that investors must inject a large amount of capital up front, before a product or service can be created that ultimately generates revenue. If the time horizon for that payback is quick, which would be the case for software, for example, then CapEx may not be that big of an impediment. However, if the payback is 5-7 years or more, there are few investors who would be willing to invest in that type of business plan.

Looking at the four characteristics of space finance – high risk, illiquidity, high capital expenditures and long-term horizons – you might ask yourself, why would anyone want to invest in space? The answer of course is that the potential returns can be enormous.

Potential Investors

Given the Four Horsemen of Space Finance, there are essentially four groups of capital available to the industry at this time: benefactors, sovereigns, strategics, and crowdfunding. These each have their positive benefits, but also their drawbacks.

Benefactors

In recent years we have seen the advent of benefactor capital. Entrepreneurs such as Jeff Bezos, the late Paul Allen, and others have put their own capital to work for the benefit of space. While this has had a significant impact on the industry, it remains small in comparison to what is required, and is by definition narrow in scope, e.g. focused on a specific part of the industry.

Sovereigns

Sovereign wealth funds are also potentially well suited to space, particularly given their long-term horizons. However, since most of the sovereign wealth in the world has complications related to both ITAR (International Traffic in Arms Regulations) and CFIOUS (Committee on Foreign Investment in the U.S.), there have been challenges with this category as well.

Strategics

There are larger companies in the ecosystem that can afford the long-term horizons and slow payback because they ultimately see NewSpace ventures as outsourced research and development. These are, of course, the larger strategic firms. While this can be a good source of capital for companies, it also puts them on a path of less independence in the future. Many entrepreneurs therefore shy away from this type of capital, choosing instead to go it alone in the capital markets.

Crowdfunding

In recent years the rise of crowdfunding has had a significant impact on global finance. Essentially these are micro-investments from typically small investors. You can think of a public company as a gateway to crowdfunding in the sense that theoretically anyone can buy shares in as little as one share denomination.

However, the recent rise in crowdfunding is typically through sites and platforms that aggregate small amounts of capital. Kickstarter is perhaps the best known of these platforms but there are many others. While these platforms are interesting and they show promise in being able to fill the gap in space finance, the capital pools are still too small to really move the needle.

In conclusion, if the industry wants to continue on the journey of creating healthy capital markets for space, the Four Horsemen need to be minimized. This will require lowering risk and reducing time horizons by engaging in more industry collaboration and standards. It will also require minimizing the number of companies that fail, and having more examples of companies engaging in successful exits (such as IPOs). Last but not least, creating more retail investor demand for space and ways for retail investors to participate will also be an important next step for the future of the industry.



Changing Global Risk Perception

LEARNING WHAT IS NEEDED TO INCREASE COMMUNITY RESILIENCE FROM THE “STRESS TEST” PANDEMIC

Prof. Hans-Peter Plag, PhD

Mitigation and Adaptation
Research Institute

Old Dominion University

Norfolk, Va.

www.mari-odu.org

Long feared by those who study global catastrophic risks (GCRs), a pandemic finally developed early in 2020. This pandemic is a stress test for human societies, and there is much to learn from it. It issues a clear warning that our societal risk perception is not well developed, and that societies often ignore the risk experience of the past, particularly for those risks and threats that impacted only other societies with little direct impacts that could have created a shared memory.

We could adhere to the warning issued by the pandemic and look at all GCRs more seriously. The pandemic also is a powerful demonstration. It showed us that nothing has to be as it is. Everything is open to choice. While we can strive to make evidence- and science-based decisions about how to tackle a global threat like this pandemic, we always have to make

and in between. She is working on risk and resilience perception and the impacts of these on risk governance. The pandemic stress test is a unique global experiment informing our research. What is written in this column is as much her work as it is mine.

Global risk experts have asked a number of

“What can we learn from the Covid-19 stress test for all the other major threats we are facing? It makes sense to ask this question now and not delay it until the crisis is over, because the way we observe the stress test will be different with this question in mind.”

choices, and these choices are impacted by our ethics, values, and biases – and in times of stress, ethics, values and biases often collide. In the end, the choices we make determine how much resilience and sustainability – how much equality and justice – will emerge from the socio-economic systems we have built.

“What if” questions concerning pandemics and other global threats in the past. How prepared a society is depends on community resilience, which in turn depends on individual resilience, and on our imagination to come up with the useful “What if” questions and the perception we have of the answers given to these questions.

The choice of moving my university into cyberspace (an example of how we attempt to be resilient during stressful times and just survive until a hopefully better ‘tomorrow’) provided me with the opportunity to spend more time contemplating at home on the stress test and to have long dialogs with my wife Shelley during breakfast, lunch and dinner,

For now, suddenly, the “What if?” has become a “Now what?” question, and almost all attention is focused on this “Now what?” But there are “What if” questions that should be asked now, while the pandemic is forcing this painful stress test.

Based on Toby Ord's recent book, "The Precipice,"¹ Anthony Andrew asked in *The Guardian* the audacious question, "What if Covid-19 is not our biggest threat?"² Threats all come with probabilities and it makes little sense to try to isolate and only focus on the biggest of them all. Therefore, I would like to ask the question, "What can we learn from the Covid-19 stress test for all the other major threats we are facing?" It makes sense to ask this question now and not delay it until the crisis is over, because the way we observe the stress test will be different with this question in mind.

If we think about society and economy, and if we accept that the purpose of a system is what it does,³ then we can make some very fundamental statements: the purpose of a society is to provide a place where the members can live and thrive in a relatively safe place. The purpose of economy is to meet our needs while safe-guarding the Earth's life-support system on which the welfare of all of us depends. If some of us start to irreversibly misuse these systems by attaching "official" purposes that are in conflict with their de facto purposes to these systems, we all end up in trouble.

In the 18th century, the official purpose of economy was defined to be the creation of human wealth without considerations for the loss of non-human (natural) wealth, and in the early 1950s this was propagated to the generation of eternal economic growth expressed in the Gross Domestic Product. In the 1970s the official purpose was narrowed down to putting the growing wealth into the hands of a few, the shareholders. The result of this official purpose of economy, which is in direct conflict with the de facto purpose, is growing inequality, more injustice, and a rapidly degrading planetary life-support system.

The official purpose attached to the societal, social and governance systems around the world varies from country to country. In the U.S., the official purpose of society was, and still is, focused on the American dream and personal liberties, and an increasingly large subgroup sees the purpose in maintaining a power structure. In Europe after World War II, many countries saw the official purpose of society in providing safety in a just and relatively equal setting of social democratic welfare states, although in more

recent times the idea of the social welfare state has been increasingly challenged. In several more totalitarian systems, the official purpose is to maintain a power structure.

The official purpose governments and people have assigned their society and their economy determines to a large extent the response to the pandemic. In societies where official and de facto purposes of society and economy are closer to each other, where societies are more equal and taking care of the people, where trust of the people in their governments and in each other is generally deeper – in most of these countries the responses appear more effective. In countries where economy and society are designed to serve the privileged few, where inequality is large and many are left behind, where access to information, data and knowledge is limited and polarized, where crime rate is high and trust is low, the responses are more ad hoc and as a result, fail to prevent widespread infections and high numbers of fatalities.

We can make difficult choices and live with them. This is what Covid-19 has shown very clearly. We even can halt large parts of the economy. We certainly could bring the official purpose of society and economy closer to the de facto purpose, which would immediately result in a change of the spectrum of possible futures, with far more

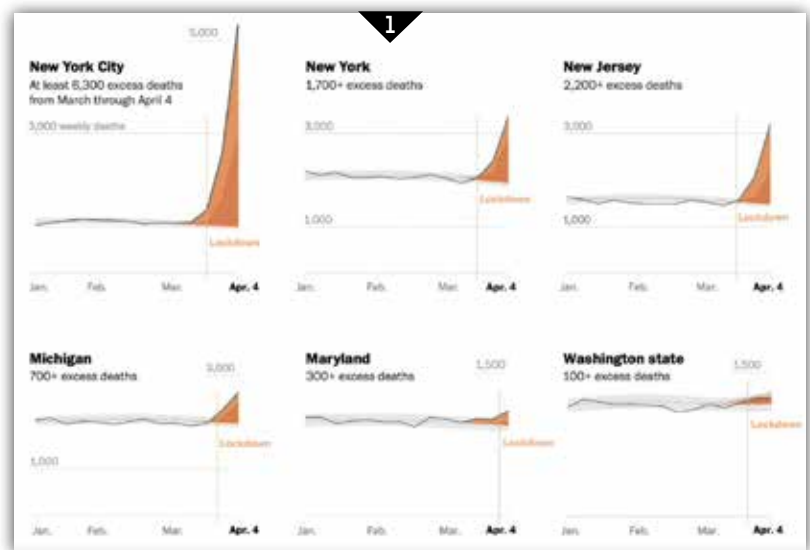


Figure 1. The excess deaths (the reported deaths minus the expected deaths based on the average over the last five years) shows for most U.S. states a large increase after the start of the pandemic, and in many states the excess deaths are more than twice as large than the deaths directly attributed to Covid-19.⁴

desirable futures open to us, including new ones not envisioned before the stress test that could become the “new normal,” although not necessarily better normals.

And we can think about what we need to know if we want to identify emerging threats better and inform our timely responses, particularly for those “X-events” that generate previously unseen system states and require transitions to new normals. What observing system could provide the data that would allow early detection and timely warnings?

In the planetary system, including humanity, all is about flows, the flow of plastics into the humansphere and from there into the terrestrial environment and the ocean; the flow of nitrogen and phosphorous into fertilizers, the agricultural fields and into rivers, lakes and the ocean; the flow of carbon from fossil fuels into the humansphere and then into the atmosphere and from there into the ocean; the flow of energy from the sun into atmosphere and ocean; the flow of misleading information through social media; the flow of viruses and other pathogens from the environment into the humansphere and within the humansphere; and, not least, the flow of humans through birth and death – into and out of the human population.

Utilizing the death reported in several U.S. states for March and April 2020 to the Center for Disease Control and Prevention (CDC), several groups found that excess deaths during the early period of the pandemic in the U.S. were in some states more than twice as high as the reported Covid-19 deaths⁴ (Figure 1) and emphasized

that this is indicating a significant underreporting. For me, it raises the question of why is this flow that the deaths represent not continuously monitored? Knowing excess deaths on a continuous basis with high spatial resolution would not only be important during times of pandemics, but also could help to detect in a timely manner impacts from environmental pollution and help to assess the true death toll of heat waves, droughts, hurricanes, wild fires, and other events and trends.

It seems surprising that monitoring the stocks and flows of shares in companies has been developed with a time resolution of seconds and early warnings of undesirable economic events are readily available. Monitoring the flows of humans through death out of the population has not, and early warnings are not available.

More generally, knowing and understanding the flows is fundamental for understanding risk and improving risk perception. Knowing which flows should be limited or eliminated, which should be increased or made redundant, and which are changing can change risk perception, inform risk management and help build a system with more resilience as an emerging property.

Knowing the stocks and flows, and understanding the processes that can change the flows and the processes that changing flows can trigger are conceptually very powerful ways to analyze a physiological system. This concept also can, and should, guide the conceptual development of an observation system for Earth viability.

A physiological system can be considered an ecosystem of many different species of stocks interacting with each other through flows. The observing system most adapted to this conceptual framework would be an ecosystem of agents that represent and provide information as needed about the stocks and flows in the physiological ecosystem.

In a recent publication we developed the idea of Intelligent Semantic Data Agents (ISDAs) that could facilitate the transformation for the current

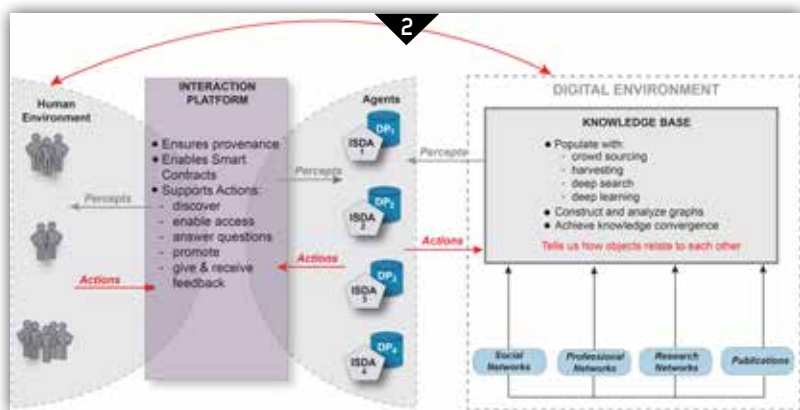


Figure 2. In the “Data as Active Subjects” concept, the different species of the ISDAs are in a digital ecosystem, and each of them represents a data product (DP). They interact with users to provide knowledge or manage access to data. The knowledge base generates graph data based on information obtained through crowd sourcing or extracted from social and research networks and publications.⁵

perception of “Data as Passive Objects” to a novel perception of “Data as Active Subjects,”⁵ (Figure 2). In fact, pairing ISDAs with sensors on all major stocks in the planetary physiological system including the biosphere, humansphere and technosphere would provide a digital ecosystem capable of providing an enormously valuable service to humanity.

Recent developments in observation technologies, the Internet of Things, crowd sourcing, communication, and information and knowledge modeling could make this possible if we make the choice to go for it. Presenting the information in a dashboard available to all of us would inform us about the viability of Earth and could guide us in our effort to ensure that the human systems we build are in compliance with the purpose of our planetary life-support system. Accepting that

“In the end, the choices we make determine how much resilience and sustainability – how much equality and justice – will emerge from the socioeconomic systems we have built.”

humans are in the driver seat of spaceship Earth, this digital ecosystem and the planetary dashboard are no longer a nice things to have – they are mandatory if humanity wants to reduce the risk not only of future pandemics but other GCRs that have the potential to end civilization. Rising from the ashes of the on-going stress test, we might want to focus on building the Earth viability dashboard.

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Acknowledgement:

This column would not be what it is without Shelley Jules-Plag struggling with me through sometimes daunting conversations about the risks we are facing; my neighbor Barry Clemson, who in frequent Zoom meetings introduced me to the fundamental works of Stafford Beer and works with me on informing about Earth viability; and my ODU colleague Cesar Ariel Pinto, who enriches my thoughts and provided stimulating comments on a first draft of the column. I am grateful to them. I am who I am in this stressful time because of them.

Hope for the Great



By Mary Jo Wagner, Freelance Writer, Vancouver, B.C., Canada

Long thought to be “too big to fail,” the Great Barrier Reef (GBR) is under serious threat and its outlook is dire.

One of the latest victims of global warming, baby coral in Australia's GBR have declined by 89 percent due to deadly ocean heat waves and mass bleaching in 2016 and 2017, according to a study published in April 2019. The ability for adult coral in the northern regions of the GBR to recover from bleaching events dropped by 93 percent – dead coral can't make new baby coral.

Further loudening the climate crisis alarm, the Australian government last August officially downgraded the health of the GBR's ecosystem from poor to very poor, publicly affirming what marine scientists already know: parts of the GBR, which has supported marine life for centuries, is now itself on life support.

3

Figure 3. The MV Kalinda sits anchored at Ellison Reef in the Central Great Barrier Reef. Two smaller boats launch from here to drop divers and snorkelers off to collect georeferenced photo quadrat data along and on top of the reef to calibrate and validate habitat maps. Credit: K. Joyce 2019.

Figure 1. Acropora species, or branching coral, growing 12 cm per year on Heron, Southern Great Barrier Reef. Credit: C. Roelfsema 2019

1



Barrier Reef

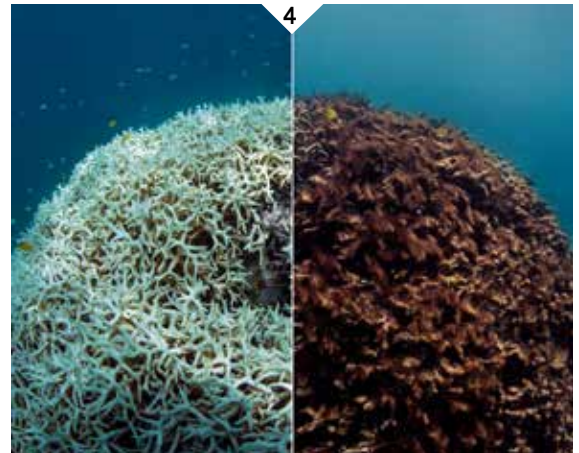
Rules Applied to Mapping Benthic Communities

2019 (C) Chris Roelfsema



Figure 2. Dr. Eva Kovacs collects a photo validation data survey within a 1m² footprint along the GBR. At the surface, she tows a GPS unit to track her position. Credit: C. Roelfsema 2019.

Figure 4. The bleaching impacts are seen on the GBR ecosystem around Lizard Island, an island on the GBR roughly 240 km north of Cairns and 27 km off the coast. In just two short months (Mar-May 2016) the healthy coral on the right turned a ghostly white. Photo credit: The Ocean Agency / XL Catlin Seaview Survey.



“The reef is definitely not as healthy as it was 20 years ago and the mass bleaching effects, particularly in the last five years, have had severe impacts,” says Dr. Chris Roelfsema, a researcher and lecturer in the Remote Sensing Research Centre, School of Earth and Environmental Sciences at Brisbane’s Queensland University. “We’ve been witnessing this decline from our research and fieldwork and there is no doubt that climate change is the culprit. There is still a lot of life along the GBR so I won’t declare that it’s dead but it is absolutely threatened and the coral, which is the support system for thousands of species, is under serious stress.”

The Need for Maps

The challenge to help conserve the world’s largest coral reef has been due in part to the lack of a complete map of the GBR’s topography, its habitat communities and different coral types. Without the big picture of a comprehensive map of the entire ecosystem, it has been difficult to dive under the surface to better understand the GBR’s life, monitor it and develop protective strategies.

A new mapping technique, however, may help scientists turn the tide. A project team led by Roelfsema combined satellite imagery, object-based image analysis (OBIA) software, coral knowledge and field data to successfully produce the world’s first-ever topographic map of the GBR’s 2,900 reefs. With this new mapping approach, scientists now not only can

“Fulfilling a 20-year-long vision, Dr. Roelfsema has combined these tools to develop a semi-automated approach to mapping the geomorphology of shallow GBR reefs and their benthic communities over a large scale.”

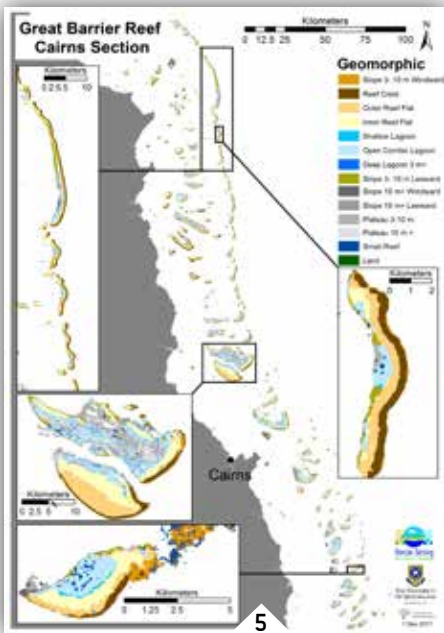


Figure 5. The results of Roelfsema’s eCognition pilot project in 2016 showing a geomorphic zonation map of 20 reefs in the Southern Great Barrier Reef, Australia. The map was derived using object-based image analysis, sub-surface reflectance and water depth from Landsat 8 OLI imagery in conjunction with significant wave height.

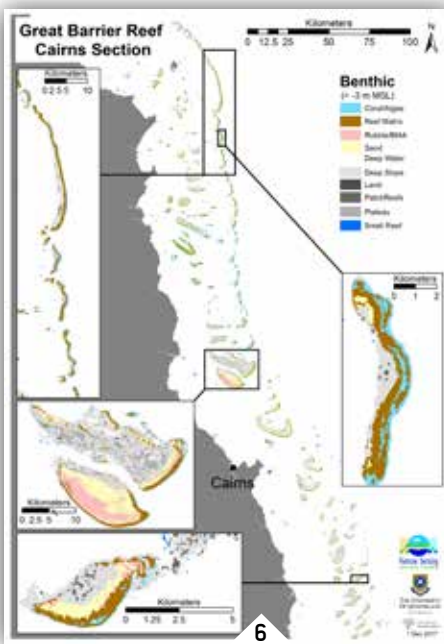


Figure 6. The eCognition-based classification and map of the benthic habitats across the 237 Cairns/Cooktown reefs, a group of northern GBR reefs about 10 to 50 km offshore that are in dire condition.

better understand where coral and specific habitat types are likely living, they’ll have the tools to start charting a path towards rescue, restoration and resilience.

Mapping Issues

Roughly the same area as Italy, the GBR stretches approximately 2,300 km along the coast of Queensland in northeastern Australia. That’s about the same length as the west coast of North America, from Vancouver, Canada to the Mexican border. A World Heritage Site, the GBR composes 2,900 individual coral reefs, 600 continental islands, 300 coral cays and about 150 inshore mangrove islands. Its intricate architecture provides a home for thousands of different species including jellyfish, mollusks, fish, sharks, rays, whales, dolphins and microorganisms.

According to the Great Barrier Reef Foundation, the GBR is valued at A\$56 billion (about US\$34.4 billion), contributes more than A\$6.4 billion (about US\$3.9) each year to the Australian economy and supports around 70,000 jobs.

Despite its significance, no systematic mapping program exists for the GBR. There is no current and comprehensive map of the individual GBR’s geomorphology (topography) or benthic composition (reef bottom flora and fauna), and the full extent of its coral habitat is not well mapped. To date, the highest quality overview map of the GBR is a 10-year-old coral reef map produced from Landsat imagery showing the outline of each reef. Although that map shows the locations of the GBR’s reefs, it doesn’t provide the thematic detail, accuracy or ecosystem depth scientists need for their work.

Underwater surveys provide meticulous records of the health and biodiversity of coral reefs, but they are costly, time intensive and only provide a narrow extent – characterizing a coral habitat of 500 square meters (about the area of two tennis courts) takes a 30-minute dive. With that method, mapping only the GBR’s 28-square-kilometer Heron Island would take three years of continuous diving. What scientists have needed is a map that marries detail and large-area coverage.

Mapping Solution

With the help of higher resolution satellites, the availability of ancillary water data, the sophistication of intelligent OBIA tools, the improvements in machine learning, and advancements in computing power, Roelfsema has been able to produce exactly that. Fulfilling a 20-year-long vision, he’s combined these tools to develop a semi-automated approach to mapping the geomorphology of shallow GBR reefs and their benthic communities over a large scale. It’s a crucial first step in helping scientists and conservationists to answer multitude questions about the world’s largest coral reef ecosystem.

“Mapping the geomorphic zones and reef habitats helps us understand how the GBR as a whole is functioning,” says Roelfsema. “We can see how it’s growing, where it’s growing and when it stops growing. We can see the composition of the reef structure and begin to assess benthic types. That foundational understanding can help identify at-risk zones and lead to better management of the GBR. It’s insight we’ve never had before.”

A Development in Waves

Since 2007, Roelfsema has been experimenting with satellite data and Trimble eCognition OBIA software to develop a scalable, coral reef mapping approach.

In 2016, he led a pilot project using eCognition technology to produce geomorphic zonation and benthic composition maps of 20 reefs covering a 250-sq-km area in the southernmost section of the GBR.

The success and promise of that study led to funding in 2017 to expand the technique across 237 reefs in Cairns/Cooktown (CC), a group of northern reefs about 10 to 50 km offshore that are in dire condition. Similar to the pilot, their aim was to classify and map the geomorphology, benthic types and coral types of these shallow reefs using similar data sources and the previously established eCognition rules. Although this would push the technique into uncharted territory, Roelfsema was confident in the software’s ability.

“The power of the software is that you can turn your knowledge into rules that it’ll strictly follow,” he says. “We can tell it all that we know about coral, reefs, slopes, waves and benthic communities and it uses those biophysical properties, pixel characteristics and spatial relationships together to classify features.”

Unique and special to eCognition is its ‘cognitive analysis.’ Similar to how our brain identifies objects, when the software classifies an object it not only considers its color or texture but its spatial relationship to neighboring objects. Adding that relationship analysis layer greatly strengthens the classification.

Unlike in the pilot, Roelfsema’s team had little first-hand knowledge of the 237 CC reefs. To collect field data, they performed dive surveys of 23 individual reefs. They recorded the topography, benthic and substrate compositions, and took thousands of geolocated photos at regular intervals while

towing a GPS device at the surface. The georeferenced photos were processed into meaningful information about each reef’s benthic communities.

They acquired three, 30-m-resolution Landsat 8 Operational Land Imager (OLI) images to cover the 3,000-sq-km area of interest (AOI). A third party used pansharpener techniques to create a 15-m seamless mosaic of the images. Using a physics-based algorithm they derived water depth, slope and wave values. Roelfsema also supplemented his own field survey data with attribute data gathered from other citizen science projects.

With the input data sources prepared, Roelfsema readied the OBIA technology, customizing the previously developed eCognition rule sets for the 237 specific CC reefs. “Once you have master rule sets, adjusting them is a simple exercise,” says Roelfsema. “It’s another advantage of OBIA. It’s flexible, it’s easily scaled and it’s easily repeatable.”

Distinguishing the Underwater Jungle

eCognition first concentrates on classifying geomorphic zones. Methodically moving from one reef to the next, it analyzes the depth values of the image mosaic and distinguishes reefs from non-reefs – any feature above 20 m is reef – to create a reef map. It then differentiates between the shallow reef top (above 3 m) and not reef top. Within the identified reef top, it classifies shallow geomorphic zones such as reef crest, inner reef flat, outer reef flat and lagoon.

Then for the deeper, not-reef zones it uses depth, wave and wind information to distinguish exposed and sheltered slopes – objects with a gradient of more than 10 degrees are slopes – and plateaus (less than 5 degrees). Once all the geomorphic zones are classified, the software uses field data and depth characteristics to differentiate benthic habitats such as coral/algae, seagrass, rock, rubble and sand.

In an additional step, eCognition divides the classified slopes into hard substrate and soft substrate (sand) and exports it as a vector layer in ArcGIS. Referencing detailed field data on coral types, along with wave, depth and slope data, a team uses an ecological model to create a predictive map of dominant coral types – branching, massive, and plate – for each reef.

In total it took eCognition only 45 minutes to produce geomorphic and benthic habitat maps for all 237 of the CC reefs.

“That’s mind blowing,” says Roelfsema. “We have never been able to map so many reefs with such little field data to that level of detail. And in such little time.”

At the end of 2017, Roelfsema presented the mapping results to GBR Marine Park Authority (GBRMPA) officials to not only validate the approach but to illustrate what this kind of information could mean for the whole GBR. Impressed by the maps, the GBRMPA invited Roelfsema to submit a proposal for mapping the entire ecosystem, and in early 2019, he was granted permission and funding to scale the methodology to all 2,900 reefs of the GBR.

The GBRHMP

A three-year initiative, the GBR Habitat Mapping Project (GBRHMP) aims to develop a comprehensive, seamless map of the GBR that details the reef’s geomorphology, its benthic habitats and specific coral types. And last October it already bore its first significant fruit: Australia’s, and the world’s, first-ever map of the GBR’s geomorphology, its slopes, plateaus and ridges along each individual reef.

Roelfsema and his team created that map based on his eCognition mapping technique, with a few modifications. Instead of Landsat, they acquired 129 Sentinel-2 images, which have a swath width of 290 km and a 10-m spatial resolution (four visible bands). Those scenes were processed into seamless mosaics, and water depth, slope and wave values were derived using the same previously established algorithm. They also collected any and all field survey data they could find on the GBR to incorporate into the classification process. To create a larger reference dataset, they applied the same eCognition rules from the initial set of 237 geomorphic reef maps to an additional 63 GBR reefs, producing geomorphic and benthic habitat maps for 300 reefs total.

Given the enormity of the GBR and the terabytes of data to be analyzed, the team switched the classification and mapping process to Google Earth Engine (GEE). Using the eCognition-based reference dataset of 300 reefs, they created a set of training and validation points. Those points were fed into GEE’s machine-learning classifier to systematically classify and produce a geomorphic map of the whole GBR. They then applied OBIA neighborhood rules to strengthen the map results.

In late October, they presented the premiere GBR geomorphic map to the GBRMPA, and although officials “loved it,” Roelfsema’s team made improvements before delivering the finalized map in December. In 2020, the team is refining the map to classify and map the GBR’s benthic communities, and in 2021, they will layer in specific coral types. All maps will be publically available through the GBRMPA.

“This map has been a dream come true,” says Roelfsema. “We’re providing more detail than scientists have ever had before. Now they’ll

be able to make spatial, ecological and biophysical connections that they haven’t been able to before. And, it’s only going to get better.”

That sounds like just the medicine the GBR needs.

Editor’s Note: For the first time, the Coral Sea has been explored with a remotely controlled vehicle, finding life beyond expectations. See <https://bit.ly/ExploreCoralSea>.

Next Stop: The World

Having proved that they can map the GBR, Roelfsema and his team have been a lead mapping partner in the Allen Coral Atlas (ACA), a massive project to produce geomorphic and benthic-type maps of the world’s 231,000 coral reefs. The ACA is funded by the late Paul Allen’s philanthropic organization Vulcan.

Using 3.7-m-resolution imagery from Planet Dove satellites, field data and geo-ecological models, Roelfsema’s team creates eCognition-based training maps that are input into Google Earth Engine for classification and mapping. Once completed, the reef maps are posted to the ACA’s online atlas (<https://allencoralatlas.org/>).

To date, they have mapped several individual reefs around Hawaii, Indonesia, Belize, Tahiti and Sri Lanka; large reef systems in the GBR Cairns region, Fiji, Tonga and Vanuata have also been done. Reefs around western Micronesia and northern Caribbean are being mapped, as well. The ACA expects to have the world’s coral reefs mapped by fall 2021.

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Garbage Patches in the Oceans

HOW REMOTE SENSING ON THE INTERNATIONAL SPACE STATION HELPS TO FIND PLASTIC POLLUTION

Among the general global population today, there is undoubtedly a high degree of awareness of the widespread pollution of Earth's oceans by anthropogenic debris (caused by humans), also called marine debris. The major component of marine debris is synthetic, petrochemical-derived plastic in various forms. The ever-growing public concern with plastic pollution has intensified efforts aimed at responsible and reduced plastic use and recycling and has further motivated research to seek alternatives to plastic.

by

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This article highlights and expands on the ideas presented by the International Space Station (ISS) U.S. National Laboratory at its second annual sustainability workshop in July 2019. The workshop focused on how remote sensing and the microgravity environment on the ISS can be uniquely leveraged in the efforts to address the global challenge of plastic pollution.

The origins and impacts of marine debris on marine and other ecosystems have long been studied. In 1997, Captain Charles Moore first discovered and reported on the existence of what is known today as the Eastern Pacific Garbage Patch, the large stretch of floating debris situated between Hawaii and California. Several major garbage patches are now known to exist, as shown in **Figure 1**. These garbage patches result from the actions of the major oceanic gyres—systems of circular ocean currents formed by the Earth's wind patterns and the forces created by Earth's rotation. The Great Pacific Garbage Patch is comprised of two distinct accumulations of floating debris within the North Pacific

Subtropical Gyre; the larger of the two accumulations is the Eastern Pacific Garbage Patch (the smaller Western Pacific Garbage Patch lies closer to the Eastern Japanese coast).

Marine debris originates from both land- and marine-based human activities. Land-sourced plastic debris enters the environment at all stages in the cycle of production, use, and disposal, enters into watersheds in proximity to densely populated coastlines, and is eventually transported into the ocean. Marine-sourced debris includes discarded fishing equipment such as nets, traps, and floats, and debris from cargo ships and oil and gas platforms that may be deliberately or accidentally discharged into the oceans.

The visible floating debris accumulations are only an indicator of the enormous scale of the pollution. Microscale and nanoscale plastic debris, which results from the breakdown of larger pieces, is now found practically everywhere—in the most remote parts of the ocean, throughout the marine food chain, in the global

biosphere, and even in geological formations. Yet, increases are projected in global demand and production of synthetic, non-biodegradable petroleum-based plastics. If a sustainable alternative is not found, plastic and other debris will continue to accumulate in human habitats everywhere.

The ISS National Lab held its second annual sustainability workshop during the 2019 International Space Station Research and Development (ISSR&D) Conference in Atlanta to gain industry perspectives and gauge interest in an ISS-based technology development effort to address plastic pollution. Participants from 13 invited large and small organizations attended, representing the following sectors: sports, aerospace, technology, agricultural sciences, retail, advanced computing, environmental, government research, and technology innovation. The two areas discussed by the ISS National Lab and invited presenters were (i) remote sensing for detection and monitoring of marine debris, and (ii) the use of the microgravity environment on the ISS for research that may accelerate the development of environmentally friendly alternatives to plastic.

Remote Sensing for Detection, Monitoring, and Cleanup Support

Space-based, remote sensing data can be applied to provide parameters for ocean circulation models used to predict the paths of marine debris throughout the oceans. Modeling studies after the Shoe Spill in the North Pacific and after the 2011 Fukushima earthquake and tsunami showed that marine debris movement can be simulated and mapped using satellite imaging. Models like the General NOAA Oceanographic Modeling Environment (GNOME) can be refined with additional, high-quality satellite data.

Editor's Note: The full report from the ISS National Lab with all references is here:

<https://bit.ly/ISSReportOceanPlastic>

Young Plastic Activists Take the Lead

Gary Benchehib

The cleanup for the rivers of the Indonesian island of Bali began when brothers Gary and Sam Benchehib's videos of floating down the dirtiest rivers on boats made of plastic bottles tied together brought the problem to the attention



of President Joko Widodo, who subsequently promised the clean the rivers of Indonesia (www.makeachange.world). Gary spoke at the World Economic Forum in January 2020. He then went to Panama to travel via bike, boat and on foot from the Pacific Ocean to the Atlantic Ocean on the Earth Vision Journey with other youth leaders to inaugurate the Geoversity School of Biocultural Leadership, which is documented on page 26 (www.geoversity.org).

Boyan Slat

Ocean plastic is being cleaned up by several ambitious organizations, including The Ocean Cleanup



(www.theoceancleanup.com), which was founded in 2013 by Dutch inventor Boyan Slat at the age of 18 in his hometown of Delft, The Netherlands.

So far, they have deployed four Interceptors, a boat structure that catches trash in the water. Shown here is Boyan Slat on the Klang River, Malaysia.

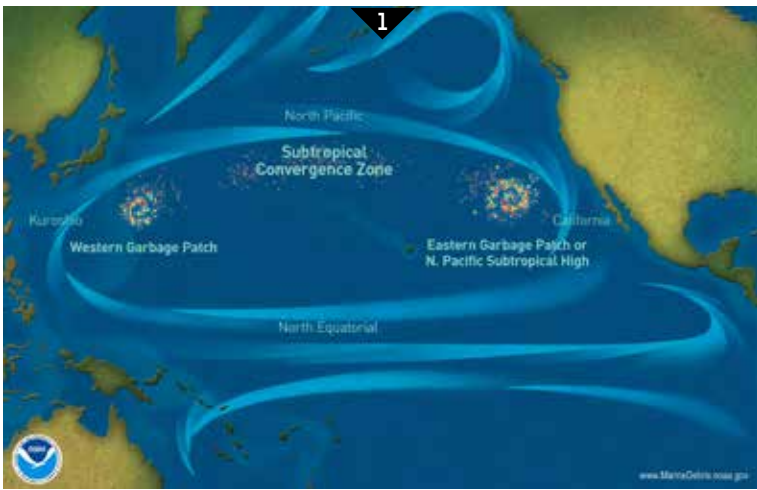


Figure 1. The Great Pacific Garbage Patch, showing locations of western and eastern patches, courtesy of NOAA.

Modeling results can be coupled with the deployment of active or emerging passive technologies for remediation, or in the future, for prevention of debris inflow into waterways and oceans. Prevention work may be performed in concert with governmental, private, and nonprofit organizations for regulation and enforcement. Another important and related potential application of satellite remote sensing data is the study and mitigation of the global spread of invasive species that are able to drift across the oceans on rafts of indestructible plastic debris.

There is global interest in remote sensing technology development for marine debris applications. Space-based remote sensing is identified as a key part of the development and operation of an integrated marine debris observation system proposed in the recent detailed review by Maximenko and co-authors from the global marine science community. Imaging spectroscopy was also identified as one of the areas of promise during a session on remote sensing of marine debris in the open ocean at the Sixth International Marine Debris Conference.

The European Space Agency (ESA) sponsored two parallel ongoing projects, OptiMAL (Optical Methods for Marine Litter Detection) and ReSMaLi (Remote Sensing of Marine Litter), focusing on passive optical spectro-radiometric remote sensing to identify the characteristics of orbiting optical sensors optimal for detection of plastic marine debris. At the University of the Aegean, the Marine Remote Sensing Group has been testing the detection of plastic using multispectral satellite imagery from Sentinel-2. Clearly, there are opportunities for global collaboration that may be facilitated by the ISS National Lab (particularly with ESA member countries that are also ISS partners) in order to accelerate remote sensing technology development for practical marine debris mitigation applications.

The ISS has an inclined orbit of 51.6°, which permits remote sensing of about 90% of the populated Earth and significant portions of the Earth's oceans with a three- to five-day average revisit time. Exterior facilities on the ISS, such as Teledyne Brown Engineering's (TBE) Multi-User System for Earth Sensing (MUSES) precision pointing platform, are available for testing prototype sensors. MUSES currently hosts the DLR Earth Sensing Imaging Spectrometer (DESIS), a hyperspectral sensor able to precisely scan the land surface, the atmosphere, and the oceans. The "equatorial"

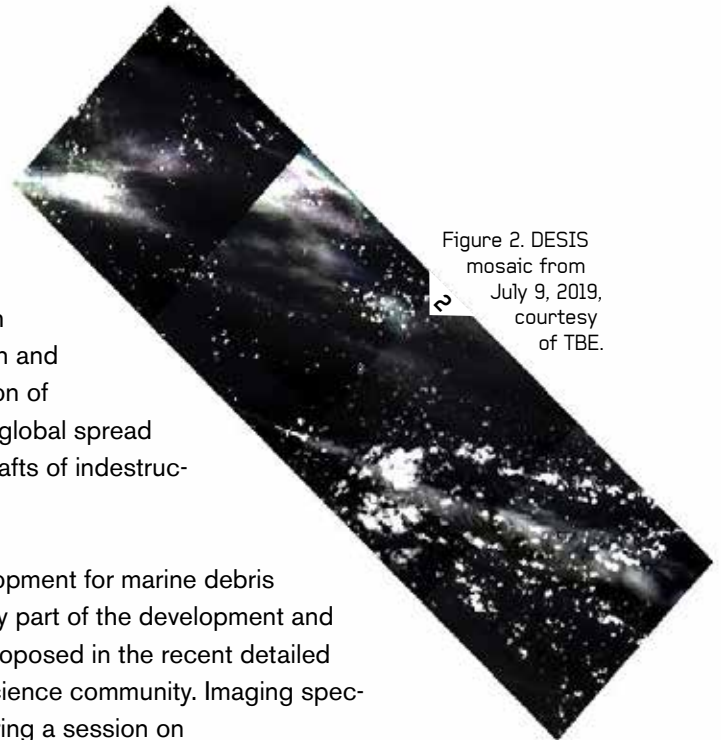


Figure 2. DESIS mosaic from July 9, 2019, courtesy of TBE.



Figure 3. Debris annotation in zoomed imagery, courtesy of TBE.

orbit of the ISS may permit tropical ocean sections often obscured by clouds to receive some cloud-free collections at high enough revisit times. **Table 1** provides a summary of DESIS key specifications, courtesy of TBE.

Table 1. DESIS Design Parameters	
Ground Sampling Distance @ Nadir	30 m @ 400 km (reference height)
Ground Swath @ Nadir	~30 km @ 400 km flight altitude
Spectral Range, nm	400 – 1000 nm
Spectral Sampling	2.55 nm for 235 bands

Just prior to the workshop, TBE tested the capability of DESIS to detect marine debris in the Eastern Pacific Garbage Patch by targeting coordinates around 32°N and 145°W. The high spectral resolution and visible to near-infrared (VNIR) spectral range of DESIS are highly desirable features that improve the chances of successful detection of marine debris. A collect with four scenes was acquired with the above coordinate center points

pixels that mix clouds and water, and while there are fewer of these pixels than of clouds or pure water, the cloud fringes were easily identified by visual inspection.

Other anomalies had a uniquely different spectral signature than the other scene contents and often appeared as clumps of brownish pixels in the water. Using these pixels, other areas were found throughout the 3,600 km² swath that show high likelihood of containing the debris content signature.

Figures 2 and 3 show the data obtained from DESIS, including a mosaic of imagery of the area for a larger view. **Figure 4** shows the quantified analysis of reflectance spectra demonstrating where the garbage is located.

Workshop participants concurred that this analysis of DESIS hyperspectral data seemed to be a step forward in detecting marine debris, and all expressed support for additional work to further develop remote sensing capability for ocean plastics using the ISS. Accordingly, with assistance from the workshop participants and other interested organizations, the ISS National Lab plans to support the following actions:

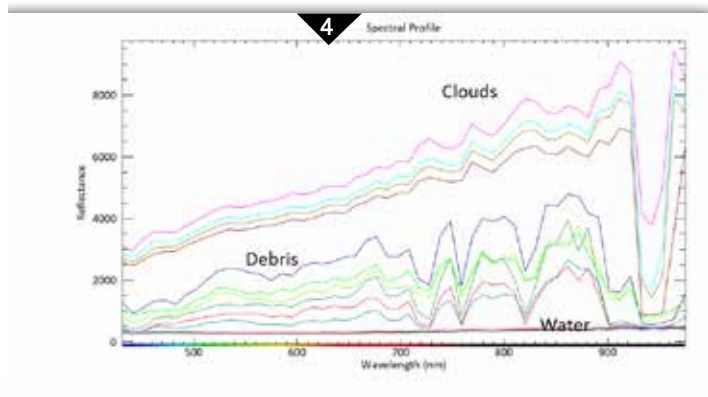


Figure 4. ENVI analysis of DESIS data showing reflectance spectra for clouds, water, and debris demonstrating location based on data value and wavelength in mn, courtesy of TBE.

on June 29th, 2019. These scenes contained a number of clouds, covered 3,600 km² of area, and included more than 4 million pixels (the entire Great Pacific Garbage Patch is estimated to cover an area up to 1.6 million km²).

Using the ENVI software from L3Harris Geospatial Solutions, the data volume was reduced by highlighting only pixels found to be “anomalous.” Once pixels were identified as anomalous, they were inspected to see if they were water, clouds, or marine debris. Pixels that included cloud edges and what appeared to be brownish mats in true color images were routinely flagged as the most anomalous. Cloud edges are

- * Using DESIS and other capable ISS sensors, collect additional data for debris accumulation targets in the ocean and along coastlines to further demonstrate detection capability.
- * Where possible, coordinate ISS sensor data collection efforts with the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping Team and organizations involved with ocean cleanup for field verification.
- * Combine and analyze ISS sensor data along with data from other space- and Earth-based sensors in order to more fully identify data gaps, develop marine plastic detection algorithms, and improve ocean circulation models for prediction of the transport paths of floating marine debris.
- * Use insights from the data analysis to assist with the design, development, and ISS-based testing of next-generation sensors that can detect and differentiate plastic debris.

The ISS National Lab will propose the formation of an advisory group to guide the development of programmatic research on the space station focused on the mitigation of plastic pollution. One area of emphasis will be on efforts to utilize data from existing or new future ISS sensors to develop the capability for detection, monitoring, and cleanup of plastic in the ocean. In the long term, new business opportunities in geospatial analysis may emerge based on unique data products from advanced plastic-debris sensing satellites.



Dispatches From the Field

We were just doing the fall issue layout of *Apogeo Spatial* when I was invited by Geoversity to work with them on the organization of their Innovation Summit: The Power of Nature, taking place at Harvard in early November. Since [that issue featured their work](#) with the University of Redlands on GIS for conservation science in Panama, I agreed to organize a panel exploring the possibilities for creating a digital earth learning and simulation platform.

Today I think back on that fateful “yes” as one of my ‘Alice in Wonderland’ moments. I would soon grow to appreciate why the founders of Geoversity speak of it as being an ecosystem with a powerful purpose. Endowed with a diverse community of talented creatives and a magical place in Panama—the 12,900-acre Mamoní Valley Preserve—it envelops you. Two unforgettably stimulating days in Boston would, in a matter of months, be followed by a week of life-changing adventures in Panama.

The Geoversity staff asked if we could team up and turn my blog posts on our experiences in Boston and Panama into a report that they could share with their extended family and beyond. So here we are!

The entries and photos in these “Dispatches from the Field” capture moments of

creativity, determination and hope, all unfolding just as the world for we humans was beginning an epochal sea change. Those recent memories already seem caught in amber, amulets from a distant past.

I hope you will find these stories, especially the vignettes of youth leaders who joined us in Panama from as far away as Bali and Bolivia, to be worth reading in this time of trial. Perhaps they can help us envision a new world—a world in which we will appreciate our lives and others on a deeper level. I see a new world where our differences will be put aside, our similarities as humans recognized, our priorities made more clear and our moments appreciated. We’ll realize that we need each other. Health and well-being will be important, and compassion and empathy for others will be inherent.

I keep thinking that the term “Life Changer” has taken on a whole new meaning, as we walk through this challenging time. The life-changing experiences that Geoversity offers are opportunities to take these new values and important lessons even deeper.

Thank you for joining me on my journey through the Geoversity ecosystem. Please take good care of yourselves, of your loved ones and neighbors of all species everywhere.

Editor's Note: This is a personal essay, which includes opinions of the author.





Dispatch From Boston

Nov. 6, 2019

Connections at Earth's Call, a Summit in Aspen, Colorado

Since meeting Nathan Gray last summer, my life has been a whirlwind of excitement and vision, as we are creating something new and ambitious on the solid foundation of Geoversity, based at the 12,900-acre Mamoní Valley Preserve (MVP) in Panama. Extraordinary people came together from around the world in November for strategic planning at Harvard, and are going in February to Panama in a culmination of all the planning and hard work. Three programs are running from February 4-12, for global youth activists on a call-to-action Pacific-to-Atlantic expedition, for young people with start-ups incorporating biomimicry into their business plans, and for business leaders seeking to gain insights from nature.

I met Nathan in Aspen last summer at the inaugural gathering of [Earth's Call](#), a new 501(c)3 organization dedicated to finding and funding innovative solutions to the climate crisis. It was an ambitious event inspired by using music to "tune" to the frequencies of the planet, vibrationally, emotionally, and intellectually, while moving people into action. Passionate and knowledgeable change-makers from around

the country were invited, and I attended via the invitation of Gina Otto.

Earth's Call was a mixture of inspirational music by icon Patti LaBelle, Mickey Hart (drummer for the Grateful Dead), and positive-message musician Colbie Caillat (known for her song "Try"), along with expert panels on subjects like tech innovation and the problems of "fast fashion," and discussions over sustenance and cocktails. Business leader (later U.S. Presidential candidate) Tom Steyer was there, as were actor Matthew Modine, documentary filmmaker David Holbrook, and blockchain company ConsenSys head of partnerships Stephen Haft. Nathan was there at the invitation of his close friend Laurie Meadoff, who was one of the producers of the event. Laurie, a founder of the New York City-based CityKids Foundation, was his partner in the early 1990s on the launch of Earth Train, youth-calling-youth-to-action train journeys and international conferences reaching millions of young people with the prescient message: "Don't wait for the adults to clean up this mess. Take action now. Create tomorrow, today."

The 2019 Innovation Summit: The Power of Nature at Harvard University



Barbara Ryan, Lee Schwartz, Michael A. Schmidt Ph.D., and Myrna James Yoo at Geoversity's Innovation Summit at Harvard's Technology and Entrepreneurship Center

Because of my knowledge of the geospatial field (having published *Apogeo Spatial* for 16 years), Nathan invited my participation in growing Geoversity, since their creation of a new project is directly relevant to my work and network. First up for me was publishing a summary of Geoversity's incredible work at their Mamoní Valley Preserve (MVP), an excerpt called "PanaMapping" from Esri's book, [GIS for Science](#), which includes carbon sequestration maps of the preserve. Next was bringing some of my top-level colleagues for a panel discussion at a meeting-of-the-minds at Harvard on November 1-2. My panel included Lee Schwartz, U.S. State Department Geographer, and Barb Ryan, former head of the global U.N.-affiliated GEO (Group on Earth Observations). I also invited Dr. Michael Schmidt, whose expertise includes aerospace medicine, [wilderness medicine](#) and team cohesion. He is becoming involved with Geoversity as a medical consultant for

the jungle and rainforest educational expeditions in Panama.

The meeting at Harvard, co-convened by Geoversity and Inovateus Solar's TJ Kanczuzewski (CEO of both), brought together a carefully curated group of people passionate about the work of the MVP and Geoversity, which is in the areas of ecology and conservation, creating with nature, and life-changing learning adventures. The real estate executive Colin Wiel, co-founder of the MVP and of Mamoní 100, with his sons, Eli and Zachary and his father Stephen, were there as long-time MVP and Geoversity supporters, serving in several leadership capacities and as inspirational examples of how entire families get involved.

Laurie Meadoff spoke about mobilizing youth, and brought her panel of experts, including Gina Otto, Chief Purpose Officer of Zero G Colony and visionary for their global tree campaign; Iva Kaufman, who promotes collaboration among funders, business leaders and NGOs; and Jonathan Gramling, co-founder of Amp.it, bringing digital video collaboration for youth around the world.

We heard about the important work of three initiatives associated with the Mamoní Valley Preserve: the drive to extend the preserve's forest and river conservancy under the leadership of TJ Kanczuzewski and Lider Sucre, the Kaminando-Jaguar Habitat Connectivity Project by Kim Craighead and Milton Yacelga, and the Harvard-based Mamoní Natural History Project created by Ben Goulet-Scott, PhD candidate. They are doing excellent

conservation work and field studies that will have important results.

Others in the room were Joe Bardenheier, Managing Partner of Brilliant Capital; Archie Kasnet, CEO of Regenerate; Mary Pearl, Dean of Macaulay Honors College of the City University of New York; Roberto Saint-Malo, Managing Partner of BetaAngels Management; Alison Sander, Director of the Center for Sensing and Mining the Future, Boston Consulting Group; and many other very accomplished professionals. Almost every board member was there, including Chair Verne Harnish, David Meerman Scott, Carolyn Kim Meenan, Shea Walsh, Stephen Wiel, Ph.D., Lider Sucre, and David Ricketts, Ph.D., who ran the show as Harvard's Innovation Fellow at the Tech & Entrepreneurship Center.



Adriano Dias Gray speaking at Geoversity's Innovation Summit at Harvard's Technology and Entrepreneurship Center

Life-Changing Experiences Await in Panama's Rainforest



Panama is the ideal setting, as it bridges continents and cultures, for three distinctly original and overlapping programs taking place in February as part of Geoversity. Twelve of the 60 people who were at Harvard are attending. Youth leaders from around the world are arriving, one directly from the World Economic Forum stage in Davos, others from Los Angeles-based MUSE School, and from the HQ of the International Indigenous Youth Council in Colorado. They will be immersed in a life-changing Earth Vision Journey 2020 and leadership program. The winners of the Biomimicry Institute's Launchpad Program are gathering to set their winning ideas on fire with the help of entrepreneurial expertise. The third program is the Power of Nature, for CEOs to hear from Geoversity leaders and best-selling authors Dr. Tamsin Woolley-Barker on how to apply the wisdom of nature to their business practices, and David Meerman Scott on the power of *Fanocracy*, from his latest marketing book.

So, Laurie and Nathan have teamed up again, as they create this new ambitious venture to be announced next week! More to come...



Geoversity is a global ecosystem of leaders and organizations collaborating in the pursuit of breakthroughs in human design, enterprise and creative expression, inspired by nature. We are working in bringing about a popular shift in worldview, away from values and practices that set humankind apart from nature towards a fully evolved oneness with nature, [geoversity.org](https://www.geoversity.org).



Dispatch From Panama

Feb. 12, 2020

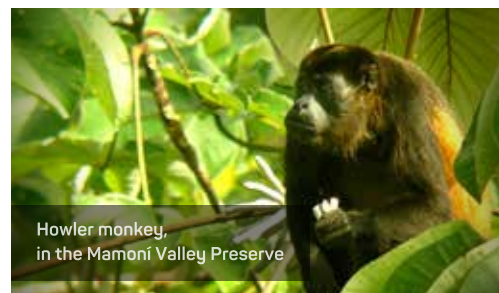
I arrived in warm balmy Panama City after watching my plane de-ice on the runway in Denver at 5:00 a.m. A few days later, Denver got a foot of snow and my son got a Snow Day. That day in Panama, I hiked down a path through dense trees that Geoversity staff and volunteers had planted 15 years prior, to swim and lounge in a refreshing pool in the Mamoní River, in a place they named Junglewood Falls. I was with inspirational youth leaders from Spain, Bali, North America, and Panama. At that moment, I was not missing the snow.

Over the past several months, Nathan had shared with me bits and pieces of what they are up to in Panama—projects which are so vast and so impactful that it was hard to comprehend at first. He said more than once, “Just come to Panama. You’ll see.” He was right. I’m attempting to put into words my heartfelt experiences, human connections and indescribable encounters with the wonders of nature.

Mamoní Valley Preserve is a magical place. It is Geoversity’s primary real-life campus of learning, just a few hours’ drive northeast of Panama City, accessible only by 4-wheel-drive and by crossing three rivers. It’s 12,900 acres of jungle and forest where magic happens, offering direct

communion with toucans, monkeys, iguanas, agutis, coatimundis, even ocelots.

As I arrived, I realized that we are standing at the threshold of a decade that will determine our future and the quality of life on planet Earth. The work of Geoversity in places like the Mamoní Valley Preserve and their new field station in the Bayano wetlands on Panama’s Pacific coast will be the drivers to course-correct the direction of humanity towards one of survival, renewal and hope. The overarching and ambitious vision of Geoversity is biocultural renewal at a global level, and a popular shift in worldview, moving away from values and practices that set humankind apart from nature toward a fully evolved oneness with nature. This vision is achieved via three areas of innovation: ecology and conservation, creating with nature, and life-changing immersive learning experiences.



Howler monkey,
in the Mamoní Valley Preserve

Dispatch from Panama

The occasion I'm sharing with you was a time in February 2020 when Geoversity organized three overlapping interrelated events—all ambitious and world-class and based on nature. First, the Biomimicry Institute brought their student winners of business ideas, and they were provided mentors to launch their businesses. Their last day overlapped with the second program, a day-long business course, "The Power of Nature: Global Leaders Applying the Power of Nature to Scale Their Organizations." The third endeavor was the Earth Vision Transcontinental Journey of youth leaders from around the world. They were chosen and invited based on their impactful work already tackling major environmental and social challenges, in order to expand their leadership skills and amplify their voices. Their journey took them from the Pacific coast of Panama up over the continental divide along the Jaguar Trail, down to the Atlantic coast of Panama's indigenous Guna and onto a tiny

island now managed by youth leaders of the Guna General Congress. I knew I was witnessing history in the making. More on that later in this post...



Iniquilipi Chiari,
Co-Founder Guna Youth Congress



Nathan Gray and the Hera executive team, Mary Pagano,
Marianela Mirpuri (Founder and CEO) and Architect Gil Bakhtiar



Architect Gil Bakhtiar, Kike Arias, Dr. Tamsin Woolley-Barker, Dr. Michael Schmidt, and Inidili Edman on the border of Guna Yala

Nathan and his team have ways of bringing together the most interesting and unique blends of people and projects. He knows how to bring the extra spice in the magical sauce that comes with mixing generations, culture (from indigenous to campesino to urban elite), and talents entwined with business, science, and the arts. I'd seen hints of the unique collaborations in images and reports from the past few years, and then at Geoversity's Innovation Summit at Harvard in November. Finally at Centro Mamoní, I was surrounded by these amazing people. With us in Panama were media-tech entrepreneur Archie Kasnet; investor Roberto Saint-Malo; best-selling marketing author David Meerman Scott; biomimicry expert Dr. Tamsin Woolley-Barker; businessman Tom Hannaher, who owns and treasures one of the world's largest collections of Guna art and plant medicine information; and Dr. Michael Schmidt, whose field is human performance and medicine in extreme environments.

Everyone who spends time at the Mamoní Valley Preserve gets to take a jungle nature hike with the incomparable expert and IUCN (International Union for Conservation of Nature) member Lider Sucre. I joined him with aeronautics pioneer (NetJets Europe and HiFly) Marianela Mirpuri, CEO & Founder of [Hera](#), and her team, Mary Pagano, Dana Al Salem, and renowned French architect Gil Bakhtiar, who are considering Panama as one location for Hera City.

Hera City will be a large sustainable smart city providing unlimited potential for women with the support of people concerned about, and engaged in, creating a better future not only for women, but for all people.

Marianela told me about their pilot program in Mumbai, India. Hera City, once approved in Panama, will be located just 12 kilometers south of the Mamoní Valley Preserve, and will include new sustainable housing. Hera City will have an Iconic Hall, world class

A Taste of the Talent

conferencing facilities, a museum featuring vernacular design, the art of Panama's native nations, and the history of women around the world. The Institute will focus on the future of humanity studies.

We learned from Lider how the queen ant of the leaf-cutter ants runs their important show in the forest, and how she looks after the others, as a sovereign. This queen ant is a model of strength and independence; perhaps she will become a symbol of inspiration for the women of Hera City.

Marianela, Mary, Dana, and Gil later went from the jungle into the city to meet with the Panamanian Government officials about locating Hera City in Panama in collaboration with Geoversity.

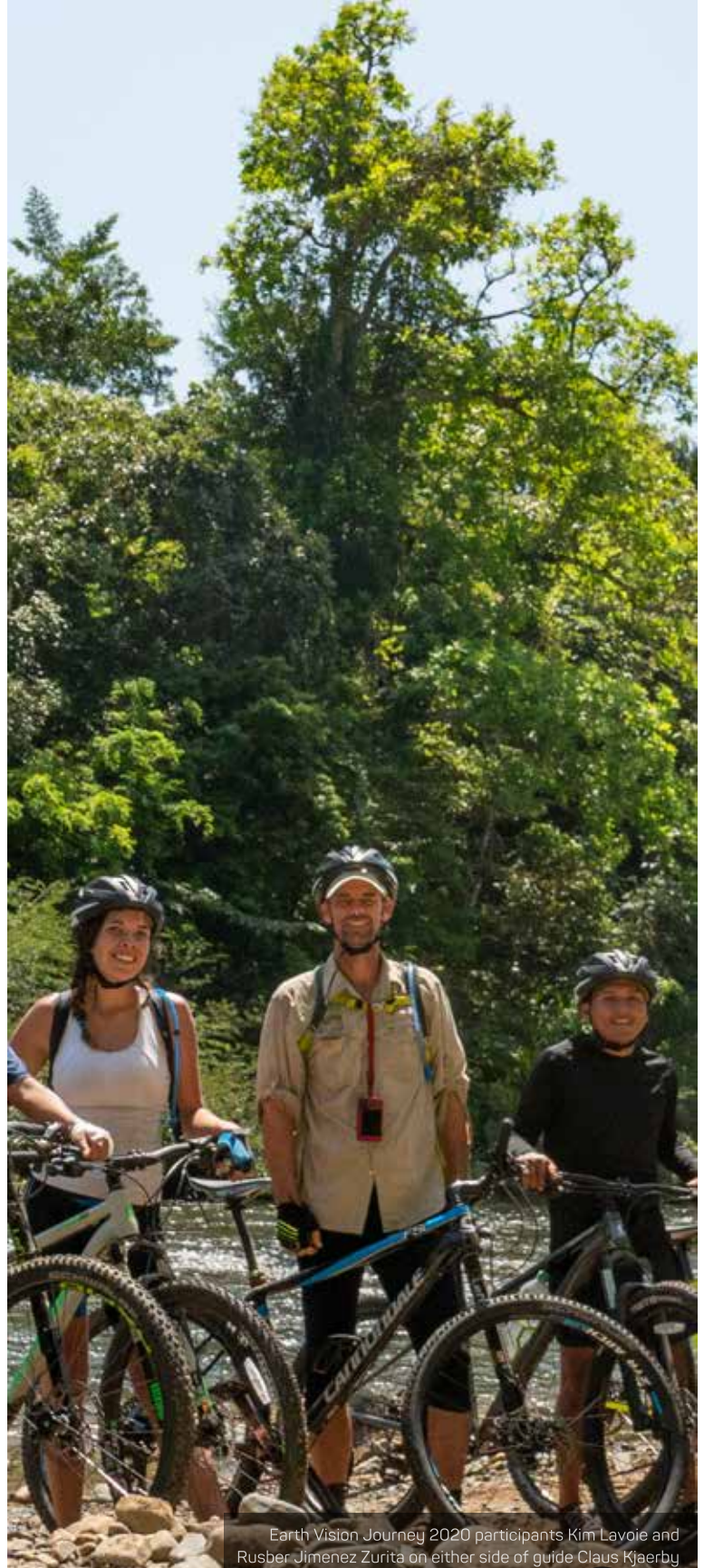
At "The Power of Nature," Dr. Tamsin presented Panama and Mamoní as "Living Bridges" bringing diverse species and cultures together for rich exchange and

innovation—opening new opportunities for ongoing evolution. She recognized that Panama's rich "sancocho de gallina" of biodiversity positions it to become a world center for Biomimicry and a much-needed biocultural renaissance—a return to the human niche of cultivating and tending diverse opportunity and exchange. We are part of the living world, and we have a vital role to play in regenerating it.



Archie's new media-tech endeavor, VIRTUAL GAIA, is an insights engine relating to the nature preserve. Their value proposition is in part a Digital Twin, or a new enhanced version of a Digital Earth with scientific data layers for education, entertainment, and social engagement. This is directly related to *Apogeo Spatial*, my magazine about using data from space to study the earth for the benefit of humanity. My knowledge of blockchain and quantum computing are also relevant to his project. I did not expect this great connection, and yet, creating connections like this is one of Nathan's gifts.

The third program was the Earth Vision Journey 2020 of youth leaders. One of them is activist Gary Benchehrib, who tied plastic bottles into kayaks to paddle down the world's dirtiest river, obtaining the promise of Bali's President to clean up their waterways! Gary founded "Make a Change World" with his younger brother Sam. They launched a series of videos and expeditions on plastic-bottle kayaks to bring attention to the world's water issues. In the past three years, with support from the World Economic Forum (WEF) and Parley, Gary's work has been seen by more than 600 million people. His speech at this year's WEF gathering in Davos earned him a standing ovation.



Earth Vision Journey 2020 participants Kim Lavoie and Rusber Jimenez Zurita on either side of guide Claus Kjaerby

Building the Foundation of Geoversity's School for Biocultural Leadership



Harvard biologist Ben Goulet-Scott speaking about the Bayano wetlands aboard Oceania's catamaran Aquarela

The main purpose of the Earth Vision Journey, produced in team with CityKids Foundation and a diverse team of internationally renowned producers, scientists, educators, artists and civic and indigenous leaders, is to promote the creation of Geoversity's School for Biocultural Leadership. The week-long journey put the spotlight on its campuses for global youth empowerment that will grow, teach, support and inspire young activists and entrepreneurs as they move forward into pivotal leadership positions. Building upon the 28-year legacy of Geoversity, they started with substantial resources that included a worldwide network of accomplished mentors, the Mamoní Valley Preserve, a new 1,000-hectare (2,500-acre) Geoversity Bayano Wetlands Conservancy in Panama, and Geoversity's Atlantic Marine Field Station in the Azores, Portugal.

A key partner in the Earth Vision Journey was Geoversity-affiliated Oceania: Expedición Mar Azul. Oceania is a two-year sailing journey around the world with eight young people as crew, exploring local solutions to global problems, accompanied by a professional film crew producing material for global broadcast.

Additional youth participating were Terrell Catt Iron Shell, Thomas Lopez, Jr., and Micaela Iron Shell-Dominguez from the International Indigenous Youth Council in Colorado, teacher Kim Lavoie and student Dylan Green of the MUSE School of Malibu, California, and indigenous environmental leaders Nayla Altamirano from Mexico and Rusber Jiménez Zurita from Bolivia. The latter two are also members of Jane Goodall's Roots and Shoots Program.

Led by Guna youth leaders Iniquilipi Chiari and Laura Huertas Thompson, the youth experienced first hand the incredible beauty, sophistication and power of nature. They began with a night sail aboard the Aquarela, Oceania's 20-meter catamaran, from the Pacific entrance to Panama's fabled interoceanic canal to the journey's starting point at the mouth of the Río Bayano. Paddling ocean kayaks the next morning, the youth traversed one of the most significant estuary wetlands on the west coast of Latin America. Then, following a Hera City dedication ceremony hosted by Hacienda Tanara, they biked uphill into the oasis in the rainforest of the Mamoní Valley Preserve to Centro Mamoní, Geoversity's science center on the southern border of the autonomous GunaYala territory. They then hiked over the continental divide and in inflatable packboats paddled down the Cangandi River and through mangroves to the Guna Atlantic coast, where they camped on the small island of Anmardup, a new model in development of eco-hospitality managed by Iniquilipi and a council of Guna youth.



Earth Vision Journey 2020 participants
paddling to Geoversity's Wetlands Field Station

Building the Foundation of Geoversity's School for Biocultural Leadership



Thomas Lopez Jr. meditating
Anmardub Island, Guna Yala

Each of the Geoversity team and participants is talented, qualified, and dedicated to making the world a better place, not just for endangered species, but for all of humanity. The Earth Vision Journey culminated with a final sharing of local food and powerful introspection in the City of Knowledge in Panama City, where we welcomed a tribe of tiny Tamarin monkeys who ventured out of the bordering national parkland forest to feast on plantains offered by Nathan's wife, Zita.

This transcontinental journey took place shortly after the 500th anniversary of the founding of Panama City. Earth Vision Journey reversed the march taken by the conquistador Balboa that resulted in the conquest of "the new world." For the youth leaders, it was their way of celebrating a millennial reversal in worldview, from one focused on conquest to one focused on natural cooperation. I observed many of these youth leaders transforming before my eyes—their outer protective shells cracked open a bit, their sharp edges softened, their smiles more genuine.



Celebration group photo at the final destination
of the trip on Anmardub Island, Guna Yala

Wisdom of the Indigenous Youth



Laura Huertas Thompson, Micaela Iron Shell-Dominguez, and Nayla Altamirano, co-leading a traditional ceremony in the Mamoní Valley Preserve.

One of the most powerful events for me was the morning hike literally following the jaguar trail up to the continental divide with Geoversity advisor Enrique “Kike” Arias, former Secretary General of the Guna General Congress; Michael Schmidt, whose close friend is a Lakota elder; Gil Bakhtiar, the French architect of Hera City; and Tamsin, our biomimicry expert.

Once we arrived at the crest of the land, we rested in hammocks as the group arrived and gathered for a sacred Lakota Chanupa ceremony, led by Thomas and Terrell. The ceremony in the jungle honored the sacred land and water of the earth. It was emotional and heartfelt, as we all contemplated the amazing gifts and life provided by Mother Earth. Kike, Iniquilipi and Laura spoke, as well.



Wisdom of the Indigenous Youth

After hearing from the indigenous youth leaders of both Panama and the U.S., I was really struck by the contrast between their histories. Ninety-five years ago, the Guna people fought successfully to keep their land in Panama, which is why today so much of their culture and way of life is preserved. In the U.S., not only was their land taken over 200 years ago, but the rights of the Native Americans were severely limited, and are to this day. The deep ancestral wound of the Lakota was present in these youth, who are leading activists of The International Indigenous Youth Council, and the Dakota Access Pipeline. They bear the weight of these histories, and carry the responsibility of creating change in a mature and inspiring way.

I spoke with Micaela about the contrast between her people's history and that of the Guna people. As I sat with her gazing out at the Caribbean Sea from the tiny uninhabited island, the last stop on the

journey, I acknowledged the wound that my people (European whites) had created when they landed on the Mayflower and eventually destroyed so many native people. As I wiped the unexpected tears running down my face, I asked her honestly, "What can we do?" After a moment, she replied sincerely, "This is helping." We will continue our conversation when we are both back in Denver, and I see us moving forward in the same direction, together.



Micaela Iron Shell-Dominguez with indigenous Guna women in the village of Can-Igar, Guna Yala



Mark Knetsch, Kandi Valle, Claus Kjaerby, Myrna Jame Yoo, Nathan Gray, Anmardub Island, Guna Yala

It's important to consider that the Guna and other indigenous people in Panama have not experienced extremes of violence and persecution. They live peacefully as they had before, in sharp contrast to the Native Americans who suffered genocide with many now living on impoverished reservations in the U.S.

Another part of the healing that is occurring is that, "we live in a time when we in the West have finally recognized the value of the indigenous perspectives on the world, a time when ancient and modern cosmologies are coming together and affirming one another," (*The Trust Frequency: Ten Assumptions for a New Paradigm*, by Andrew Cameron Bailey and Connie Baxter Marlow, p. 183, 2012).



Micaela Iron Shell-Dominguez and Rusber Jiménez with biologist Ben Goulet-Scott on Anmardub Island, Guna Yala

“

With the gorgeous backdrop of Panama, Geoversity's programs of biodiversity and cultural immersion coupled with CityKids' 35 years of transformative leadership training, and partnering with the training partners of Planet 911 and Expedición Oceania, we amassed an army of social change agents. These youth leaders experienced a life-changing connection with the Earth, and with rural and indigenous peoples, through Geoversity. They also learned leadership skills and are being supported as they are emerging as the new leaders of the climate movement. The Geoversity School of Biocultural Leadership will become an international community of purpose dedicated to the empowerment of young activists and 'architects of the future'.

-Laurie Meadoff,

Founder, CityKids, Co-Producer, Earth Vision Journey 2020

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Changing the Paradigm with a Biocultural Renaissance

For me, an ideal life is one living on purpose, in the moment, in flow with the universe, with my heart engaged. Immersing in the MVP offers a rare physical reality of these concepts. For me, and I believe for most of us, that's why it's a life-changing experience. Being there reminded me so much of my life-changing course-correcting 18-month solo trip around the world over 20 years ago—pure magic!

Geoversity provides opportunities for people to come to Panama, to be in the magic of nature and experience it in a completely new way, immersed in the textures and sounds of the forest and rivers. Under the expert management of Geoversity's COO Claus Kjaerby and his Life Changer program team, Mark Knetsch, Anna Gili and Kandi Valle, these journeys outside of ourselves connect us to deeper meaning as we experience the interconnection among all living things. As Eckhart Tolle observed, *"There is a power at work in nature that humans have lost touch with. It is the creative power of the universe... While nature is a beautiful expression of the evolutionary impulse of the universe, when humans become aligned*

with the intelligence that underlies it, they will express that same impulse on a higher, more wondrous level," (*A New Earth: Awakening to Your Life's Purpose*, p. 268, 2005).

The Mamoní Valley Preserve and Geoversity grid of life-changing expeditions within Panama provide the settings and challenges to engage the heart, expand our worldviews, and raise our consciousness—about other cultures, about the magnificence, beauty and power of nature—and perhaps most poignantly, about ourselves and our place in the world. These experiences are creating the paradigm shift that is so needed in the world today. Geoversity is the portal to a future that includes an incredible biocultural renaissance.

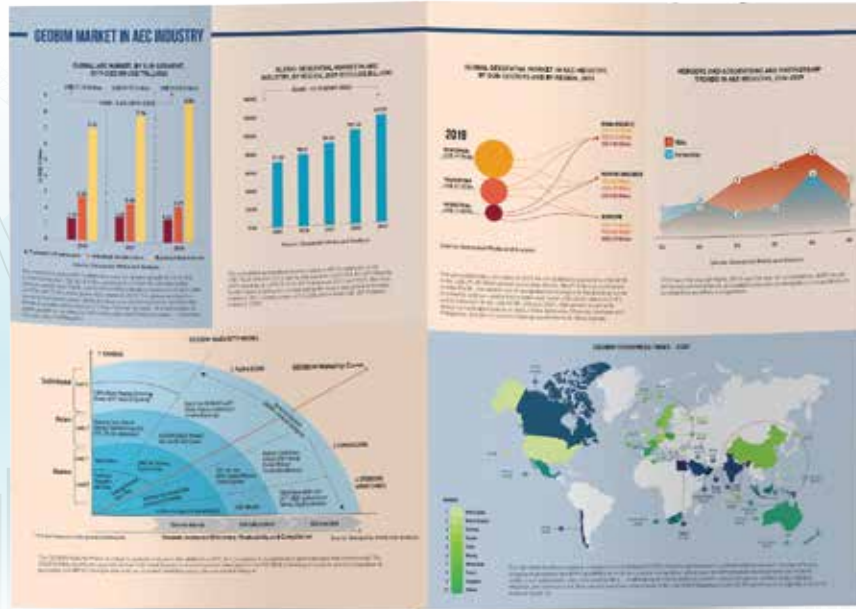
Imagine yourself contributing to a new world by having your own life-changing experience in the jungle of Panama! Join us in these endeavors, in whatever way that fits for you. Reach out to see how you can join our diverse community of purpose: Myrna@ApogeoSpatial.com
info@geoversity.org.

“

How fitting that Geoversity's global chair is the famous business educator and founder of the Entrepreneurs' Organization (author of world best-selling book, *Scaling Up*) Verne Harnish. For 28 years Geoversity (formerly [Earth Train](#)) has quietly been doing excellent work, and in Panama since 2001, building their impressive programs and increasing their land conservancy campuses for education and breakthrough innovation. Now, all the pieces of the puzzle are in place for a major scaling up under the banner of the Geoversity School of Biocultural Leadership. And the emerging picture is more powerful, real, and beautiful than I ever expected!

-Myrna James Yoo

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GEOBIM MARKET IN AEC INDUSTRY

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Progress documentation, transport planning, and site layout efficiency are few of the benefits of EO data in AEC industry

Drones, are the future – especially in post Covid-19 era

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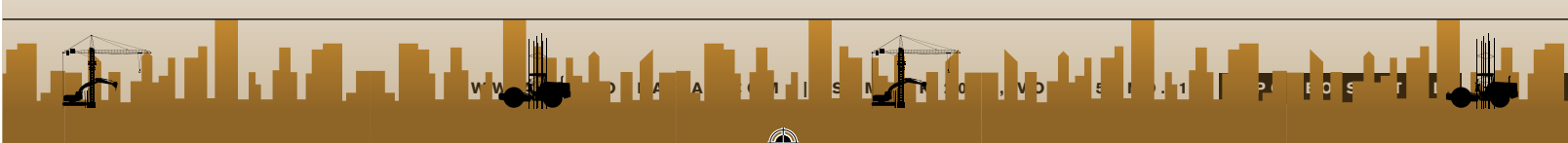
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