

RENEWABLE RESOURCES JOURNAL



VOLUME 30 NUMBER 3

CONTENTS

How to Prosper in the Rare Metal Age.....	2
<i>David S. Abraham</i>	
A Flood of Choices: Considering Privatization of Water Utilities.....	10
<i>Daniel J. Van Abs</i>	
The Case for Cosmetic Safety Reform.....	13
<i>Scott Faber</i>	
Implications for U.S. National Security of Anticipated Climate Change.....	16
<i>U.S. National Intelligence Council</i>	
News and Announcements.....	22
Meetings.....	31

WWW.RNRF.ORG

How to Prosper in the Rare Metal Age

David S. Abraham

Introduction

Rare metals are everywhere—really everywhere—from soaring bridges to earphone buds. They are in couches, camera lenses, computers, and cars. But they are rarely used alone or as the primary material. In essence they fill a role similar to that of yeast in pizza. While they are only used in small amounts, they're essential. Without yeast there's no pizza, and without rare metals there's no high-tech world.

We lack awareness of them because we never directly buy them as we do other commodities such as gas or corn. Rare metals are buried away in components that are essential to almost every gadget we use, like the rare earth permanent magnet. While the production of permanent magnets is approximately a mere \$15 billion market today, if we were to add together the value of all industries that rely on these magnets—automobile, medical, and military—the sum would reach trillions of dollars.

To paraphrase a slogan of the chemical corporation BASF, rare metals don't make the products we buy; they make the products we buy smaller, faster, and more powerful. They made [Steve] Jobs's iPhone thinner, more functional, and more mobile. This is because each rare metal has its own characteristics that serve very specific functions. For

example, it can be malleable (indium), ductile (niobium), toxic (cadmium), radioactive (thorium), or magnetic (cobalt), or it can melt in your hand (gallium). And like characters in the X-Men comics, they all have their own superpowers. Terbium produces more vibrant light in television; dysprosium and neodymium make incredibly strong magnets possible; antimony helps resist fire.

Among the elements in the periodic table, roughly two-thirds are metals or metalloids, elements like silicon that share some characteristics of metals and

Rare metals are no less transformative than oil or coal.

nonmetals, and are most valuable because of their semiconducting properties. Of these, mines produce millions of tons each year of the best-known metals, like copper and zinc, which are called "base metals." Others, like gold and silver, have retained value for centuries, hence their name "precious metals."

Rare metals are in an umbrella category for almost all other metals. Their defining feature is that they're consumed in small quantities, hence "rare" when compared to base metals. On average, the world consumes individual rare metals in the hundreds or thousands of tons annually—the annual production of each can fit into just a few rail cars. By comparison, miners produce about 1.4 million tons of copper annually. According to data from the U.S. Geological

Survey, if you add up the annual consumption of all materials that are considered rare, the amount would be substantially less than the quantity of copper consumed every year. The label "rare" does not mean that these metals are all geologically scarce. Indeed, some are plentiful. Others are abundant but seldom found in concentrations high enough to be mined profitably. To complicate labeling matters further, some in the industry call them "advanced" or "technology" metals because of their prevalence in electronic applications. Others call them "strategic" or "critical" because of their irreplaceability in their applications. Those who trade these materials alternatively call them "minor."

Rare metals also encompasses rare earth elements, a set of seventeen atomically similar metals, which gained international attention in 2010, when fears of Chinese monopolistic control of production and export restrictions drove prices up nearly tenfold. Rare earth elements are a mere subset of rare metals but they share many of the same market dynamics. For example, many rare metals, like rare earths, must undergo challenging refining techniques. They are also traded in backroom deals rather than on open exchanges like other commodities such as oil.

If naming them is a challenge, classifying which metals are "rare" is even more problematic. Even the Minor Metals Trade Association, the organization that trades these metals, lacks a standard definition. By its count, members now trade forty-nine rare metals, up from eight just three decades ago when manufacturers bought only a handful of them. (Many insiders can't even agree as to what is a rare metal and quibble about

Abraham is director of the Technology, Rare and Electronics Materials Center. This article is adapted from his book "The Elements of Power: Gadgets, Guns, and the Struggle for a Sustainable Future in the Rare Metal Age." The book won the 2016 RNRF Excellence in Journalism Award.

whether a specific metal should be labeled as such.)

But don't let the lack of an encompassing term or the small production levels fool you into underestimating their economic and geopolitical importance. These tiny quantities of metal have fostered incredible technological change. Rare metals are the base of our modern high-tech, green, and military industries. Rare metals are no less transformative than oil or coal. They will increasingly deserve the same attention we afford fossil fuels, meaning those who control and manage their production and trade will increasingly reap outsized economic and geopolitical fortune. And yet, unlike oil or coal, they are often more limited in supply and far more complex to produce, and they originate from just a few places on earth. Many have such unique properties and uses that they cannot be switched out for cheaper or more abundant alternatives. Our reliance on rare metals is not just an abstract geopolitical issue or a topic of concern only to material scientists. It is a potential source of conflict.

Based on our current rate of rare metal resource production and our consumption patterns, we won't have the dysprosium necessary to build magnetic resonant imaging (MRI) machines; yttrium critical for military radar; or the tungsten for oil exploration drill bits. New high-tech inventions will only add urgency to expand our limited supply chains, meaning the future supply of materials for our gadgets is at stake. Numerous recent government and think tank studies highlight the risk of shortages over the next decade and some even longer. The American Chemical Society finds that over the next century, forty-four of the ninety-four naturally occurring elements face supply risks. While production levels of many elements will rise to meet demand, their report highlights a real concern.

The future of our high-tech goods

may lie not in the limitations of our minds, but in our ability to secure the ingredients to produce them. In previous eras, such as the Iron Age and the Bronze Age, the discovery of new elements brought forth seemingly unending numbers of new inventions. Now the combinations may truly be unending. We are now witnessing a fundamental shift in our resource demands. At no point in human history have we used

Rare metals are key ingredients in green technologies such as electric cars, wind turbines, and solar panels.

more elements, in more combinations, and in increasingly refined amounts. Our ingenuity will soon outpace our material supplies.

This situation comes at a defining moment when the world is struggling to reduce its reliance on fossil fuels. Fortunately, rare metals are key ingredients in green technologies such as electric cars, wind turbines, and solar panels. They help to convert free natural resources like the sun and wind into the power that fuels our lives. But without increasing today's limited supplies, we have no chance of developing the alternative green technologies we need to slow climate change.

Our demands are now pushing against the bounds of what we can sustainably produce. Fluctuations in the complex supply line will affect society in unpredictable ways. New supplies of dysprosium could speed the development of highly efficient wind turbines, and conversely, a lack of it could drive up the

cost of hybrid vehicles. It's no understatement to say that our use of rare metals will determine the fate of the planet.

How to Prosper in the Rare Metal Age

In 1970, yellow legal pads, typewriters, and double-stacked in- and out-boxes covered desktops, not icons. Although computers had yet to make their appearance on the average desk, a resource change was coming. Centronics introduced the dot matrix printer, Intel began selling microchips, and programmers had just sent the first e-mail message on ARPANET (Advanced Research Projects Agency Network), the roots of today's Internet. A few years later, George Pake, who headed Xerox Corporation's Research Center, predicted that by 1995, TVs attached to keyboards on office desks would strike the death knell for paper. "I'll be able to call up documents from my files on the screen, or by pressing a button," he said. "I can get my mail or any messages. I don't know how much hard copy printed paper I'll want." As it turns out, he'd want much more.

Despite all the high-tech gadgets that appear to negate the need for paper, paper use in America has nearly doubled since Pake's days. We now consume more paper than ever: 400 million tons globally and growing. That's roughly 2 pounds of paper per office worker every day.

Paper is not the only resource we are using more of. Technological advances often come with the promise of using fewer materials, but the reality is that they have historically driven more materials use, making us reliant on more natural resources. The world now consumes far more "stuff" than it ever has. We use thirty-four times more construction minerals such as stone and cement and twenty-seven times more ore and industrial minerals, such as gold, copper,

and rare metals, than we did just over a century ago. We also each individually use more resources. A person today consumes more than ten times the amount of minerals than one did at the turn of the twentieth century. Much of that is due to our high-tech lifestyle.

In the 1980s, Americans huddled around a TV, maybe an Atari game system. Today entertainment flat-panel systems are hooked up to DVRs, speakers, and game systems replete with cameras and motion sensors. The cassette and record players of past years have been relegated to the antique stores, but many new products complement existing ones rather than rendering them obsolete. The microwave revolutionized the western kitchen but it did not replace the stove, oven, or grill. Likewise, since the tablet computer and smartphone sync with each other, we find them complementary despite their similar functionality. Americans seem to have little trouble with this redundancy: even in 2013, more than a third of Americans owned a tablet, laptop, and smartphone. Meaning Americans are purchasing a lot of gadgets. According to Consumer Electronics Association, the average U.S. family owns twenty-eight different electronic devices not including kitchen appliances, power tools, or washing machines.

For proof of this consumption pattern globally, we need to look no further than our trash. The amount of electronic waste the world is producing is growing at an estimated 17 percent annually, even though total amount of waste collection in some countries has leveled. We are on a global trajectory to toss out over a billion computers annually. This is not just because we have more of these devices but because we use them so briefly. The average lifecycle of a smartphone is about twenty-one months. Likewise, laptops, tablets, and many of our high tech gadgets have life spans of less than three years. This is not because the product is useless when we junk it

Renewable Natural Resources Foundation

The Renewable Natural Resources Foundation (RNRF) is a nonprofit, public policy research organization. Its mission is to advance the application of science, engineering and design in decision-making, promote interdisciplinary collaboration, and educate policymakers and the public on managing and conserving renewable natural resources. Member organizations are:

American Geophysical Union ♦ American Meteorological Society ♦ American Society of Civil Engineers ♦ American Society of Landscape Architects ♦ American Water Resources Association ♦ Geological Society of America ♦ Society of Environmental Toxicology and Chemistry ♦ Society of Wood Science and Technology

RNRF Board of Directors

<p>Chairman: Richard A. Engberg American Water Resources Association</p> <p>Vice Chairman: John E. Durrant American Society of Civil Engineers</p> <p>Executive Director: Robert D. Day</p> <p>Directors: Sarah Gerould Society of Environmental Toxicology and Chemistry</p> <p>Erik Hankin American Geophysical Union</p>	<p>Paul Higgins American Meteorological Society</p> <p>Lu Gay Lanier American Society of Landscape Architects</p> <p>Howard N. Rosen Society of Wood Science and Technology</p> <p>Barry Starke Public Interest Member</p> <p>Kasey White Geological Society of America</p>
--	--

Renewable Resources Journal

Renewable Resources Journal (ISSN0738-6532) is quarterly of Renewable Natural Resources Foundation, 6010 Executive Blvd, 5th Floor, North Bethesda, MD 20852-3827, USA Tel: +1 301 770 9101. Email: info@rnrf.org. Website: <http://www.rnrf.org> © RNRF 2017.

Annual digital subscription rate is \$20. RNRF assumes no responsibility for statements and opinions expressed by contributors. Permission is granted to quote from the journal with the customary acknowledgement of source.

Editorial Staff: Robert D. Day, editor; Nicolas H. Kozak, assistant editor

but because its obsolescence, in many cases, is by design.

iFixit, a site dedicated to repairing those irreparable high-tech gadgets, notes, “Apple is making billions by selling us hardware with a built-in death clock,” referring to a built-in battery that iFixit believes starts to lose power just as the warranty ends. To replace the smartphone’s battery, you must either go to an Apple store or mail the phone to Apple along with \$80. As few people are willing to forgo their phone for the time it takes to repair, they are more likely to upgrade. American mobile telephone companies also institutionalize minor

metal consumption by offering to provide a new, “free” phone as frequently as every six months. Because of this, product life cycles are now measured in months not years. And this has a profound effect on our resource use.

According to a Japanese industry study, in the 1970s the average commodity had a life cycle of five years and about 80 percent of all the materials in them had a life cycle of at least three years. Just after the turn of the millennium, that dynamic nearly flipped. Twenty percent of all commodities were discarded in one year, and half, in less than two years.

Today consumers also find it far easier to buy many high tech goods because by comparison they are cheaper, in some cases drastically cheaper compared to other items such as food. Since the early 1980s, the consumer price of a television and other video equipment fell by more than 90 percent. But these trends don't even address what might be the biggest use of rare metal resources: the technology of the future.

With a sprinkling of rare metals, Robert Tenent, senior scientist at the National Renewable Energy Laboratory in Golden, Colorado, turns no-tech glass into high-tech windows. Tenent's windows allow the sun's light to shine through, but not its heat, or alternatively, the sun's heat, but not its light. Sometimes the windows keep both out—flip a switch and they darken within five minutes. The windows are part-curtain, part-insulation, and undoubtedly contain advanced technology. Tenent's secret ingredients are a few grams of tungsten and indium.

His windows are part of the laboratory's showcase building—an office of 33,445 square meters that uses no external electricity, so keeping cold in during the summer and heat in during the winter is crucial. Tenent's windows are not just good for the lab; they present a great green opportunity: replacing old energy-inefficient windows can save up to 4 percent of all energy consumed in the United States. But at the same time, the windows present a tremendous challenge for our rare metal supply lines because the United States alone has more than 1,813 square kilometers of traditional windows. The windows mark the next stage in the Rare Metal Age when demand soars: when the infrastructure that underpins our modern lives becomes high-tech—fleets of electric buses, roads built out of solar panels, or elevators that rely on magnets instead of cables. Michael Silver, the chief executive officer of American Elements, a materi-

al science company, tells me, “The spigot [of ideas] is on full blast. You start seeing astronomical volumes of material ten years out.”

New innovations include not only new products but also existing technologies used in new ways. Imagine the interior walls of a bedroom lined with flat panels that change color to adjust your mood. Or bathroom “mirrors” that display your body's vital signs gathered from sensors and cameras around the house. General Electric foresees a kitchen designed around a hub with a cooking surface that uses voice, motion, and facial recognition to help you share

Our demands [for rare metals] are now pushing against the bounds of what we can sustainably produce.

your culinary creations with others via the Internet.

These products may seem far off, but for some perspective on how quickly new technologies can proliferate, look back at the smartphone. In just four years after its introduction, 6 percent of the world population owned one, making such phones, by some metrics, the fastest growing technology ever. A few years later, the tablet accomplished the same feat in half the time and now nearly half of all Americans own one. This rate of technological penetration is the new norm and it drives up rare metal use. Cisco, the American network equipment company, reports that in 2010 over 12.5 billion devices were connected to the Internet. That number will quadruple by 2020 to 50 billion. Interconnectivity will drive rare metal demand, not just for the products themselves, but also for the

infrastructure to power them. This is especially true if it's new green technology.

At the same time that the wealthy world is using more rare metals, the speed at which developing countries are playing technological catch up is unprecedented. For example, in 1995, only 7 percent of Chinese city dwellers owned refrigerators, twelve years later, 95 percent of them did.

The U.S. government's National Intelligence Council predicts that the global middle class may nearly triple over the next two decades, adding roughly two billion more people—the equivalent population of roughly two more Chinas or six Americas. “Such an explosion will mean a scramble for raw materials and manufactured goods,” a 2012 council report says. Add to this our global quest to find green energy alternatives, and the demand for rare metals will soar. The Japan Institute of Metals, meanwhile, reports that demand for rare metals like cobalt, tungsten, and lithium will increase by a factor of five by 2050, and will outpace our current reserves for many of them.

The coming resource crunch raises the likelihood that resource-rich countries will use their own increasingly valuable resources to gain strategic and economic advantage. This portends tense showdowns between individual companies and countries as these countries continue to tighten their control over the metals, or worse, cut rare metal trade again. All this resource use scares Roger Agnelli, former president and CEO of the mining giant Vale. As he told me in 2013, “The reality is the planet is very small for the number of inhabitants we will see in 2025. As technology is getting cheaper, resource demands are increasing and we are facing changes in geopolitics. This is real.”

And yet, I would argue, the answer to our concerns about rare metals is not to shy away from using them because of

our geopolitical supply fears. Rather it is to search for more sources, use them more efficiently, and advance our knowledge of geology, metallurgy, and material science.

To deal with potential resources shortages, we must think about minor metal supply in several dimensions. The world, and indeed each country, needs a secure supply of sufficient resources, at minimal environmental cost, arriving through resilient supply lines. Therefore, we need to turn rare metals into commodities—we should strive to make them cheaper, more abundant and produced with the least environmental impact. That means international efforts are critical, including to develop, understand, and improve material development and flows; to invest in education regarding the use and conservation of resources; and to adjust regulations to better govern the start-up of new mining operations.

In the Rare Metal Age, we either need to get better at predicting the future or set up robust supply chains for a variety of rare metals that could possibly be in demand (or both). But the track record of our experts in predicting the technological future is muddy at best.

- “Television won’t be able to hold on to any market it captures after the first six months. People will soon get tired of staring at a plywood box,” Darryl Zanuck, founder of Twentieth Century Pictures (1946).
- “There is no reason anyone would want a computer in their home,” Ken Olsen, founder of Digital Equipment Corporation (1977).
- “I predict the Internet... will soon go spectacularly supernova and in 1996 catastrophically collapse,” Robert Metcalfe, founder of 3Com and the Ethernet (1995).

Since we don’t know which invention will take off, we can’t estimate which rare metal will either. Thirty years ago,

dysprosium had little use. Now, in part because of its use in magnets, it is essential for our new high-tech lives. Gallium, because of its low melting point, could find itself in high demand in 3D printing, a type of home-based manufacturing. Or gadolinium, a sister element to dysprosium, has long shown promise in a magnet to produce energy-efficient cooling. This future technology could revolutionize the refrigerator market, putting that appliance within reach of the billions who do not now have one. Or it may always be a technology of the future.

Rather than predicting the future, we should prepare for it. And for that we need to mint more people like Toru Okabe. Okabe, a Tokyo University material science professor, is so enamored with titanium that he gives it out as gifts. When we met at a conference in southern China, he handed me a small sealed bag with a thin titanium coil to explain the concept of shape memory. (He told me that if I stretched out the coil, it would return to its original shape, which makes titanium useful in glass frames, for example.) Titanium is not just a material science toy, it has an abundance of uses and if it were less expensive it would transform our resource demands because titanium is stronger than steel, 45 percent lighter, and corrosion resistant.

The challenge involved in titanium, the fourth most common metal in the earth’s crust, is that it’s expensive to produce because of the high temperatures needed in processing, making it environmentally taxing. Okabe wants to improve titanium’s processing efficiency and turn it into an abundant commodity. If he succeeds, a fraction of titanium could replace steel in bridges, buildings, and even tools. Titanium could be the green alternative. Products that use titanium instead of steel would require less metal, which means less mining and greatly reduced carbon dioxide emissions.

Okabe has a leg up on researchers elsewhere. He lives in Japan where his university receives a modicum of government support, whereas most metallurgists elsewhere have been less fortunate. In the United States, since the government shuttered the Bureau of Mines in 1995, Colorado School of Mines professor Patrick Taylor has had almost no way of securing government funding to support extractive metallurgy research. So he must increasingly work with industry from overseas. Funding is crucial, but as the industry is focused on the bottom line, corporate funders are not interested in experimental research, the kind of work that pushes frontiers, as Taylor tells me—the research that can truly revolutionize the industry. For Taylor, U.S. government support would be a boon. Furthermore, the amount of electronic waste the world is producing is growing at an estimated 17 percent annually.

Beyond economic growth, the world needs more university-level mining, metallurgy, and material science programs to help alleviate the shortage of mining and metals professionals. They are needed to create the scientific breakthroughs that the world demands. Increased government support is crucial, but it is not enough.

Unfortunately, our best and brightest who have material science and physics degrees aren’t conducting research. They head off to Silicon Valley or Wall Street, Elisa Alonso, a former Massachusetts Institute of Technology material scientist, tells me. When I ask her whether many of her colleagues will stay in material science after nearly a decade of study, she laughs, “You are not going to do that.” The other jobs being offered are too exciting and lucrative to turn down. We need to bring prestige and romance to toiling with metals and to start companies that ask big questions, which only advances in material science can answer: for example, how to commercialize space travel.

Visionaries like Elon Musk, the co-founder of PayPal who was admitted into Stanford's material scientist doctoral program, has started companies that ask just those questions, Tesla and Space-X. We need more of them. Simply, we need to create excitement around material science as we have for entrepreneurship. Now 70 percent of millennials want to work in more entrepreneurial endeavors outside a corporate structure. We need that same level of excitement for science so Alonso's colleagues will stay in the field. They are not only critical to finding new breakthroughs with rare metals, but also in developing ways to be more efficient with the metals we currently use, as well as discovering more abundant and greener materials that can limit our growing dependence on certain limited resources.

While research is crucial to unlock material science secrets, we also must change consumer habits and business models to ensure sustainable supplies of resources. Therefore, we need to fundamentally change our relationship with our gadgets; we cannot continue to buy a new smartphone when the battery dies. Our gadgets must last longer. Changing a cracked Smartphone screen must become as simple as changing a battery in a remote control. High-tech repair services need to be as ubiquitous as dry cleaners. Companies like Apple, which make lengthening the life of its products difficult, must play a role in prolonging the lifecycle of its products by selling component replacements and providing easy access to materials under the hood. In essence, it needs to open its products ecosystem to help save our planet's.

Selling fewer products that last longer may sound as if it is anathema to a market economy; it's not doom and gloom. For Caterpillar, which began a remanufacturing program in 1972, taking back equipment is a core part of its business. In fact, remanufacturing helped the company to open markets in the devel-

oping world and provided new profits because remanufactured products are less costly to produce and they sell for up to 60 percent of the price of a new tractor. Companies could also lease products much the way car dealerships do, taking the product back after use. They need to put as much effort into the end-of-life care of their products as they do into its functions.

Governments need to hold companies responsible for the effects of their products. One company that recycles millions of phones is easier and creates more profit opportunity than would be

*To avoid future
conflict, it would be
useful to address rare
metal supply concerns
in a global forum.*

achieved by asking millions of people to recycle one phone each. Not only is it more efficient, it creates recycling feedstock and economies of scale that help create a profitable recycling supply chain.

Regulators would do well to require companies to include afterlife care as part of the products they make as Dell Corporation does. Mandating that companies must recycle their own products encourages companies to more efficiently use materials—especially rare metals; to design products that are easier to recycle or reuse; and to develop less environmentally harmful and more easily recycled alloys. Efficient recycling will extend the life cycle of rare metals and reduce the need to dig for more. But only one quarter of U.S. electronics end up in effective recycling systems. Now, in places like South Portland, Maine,

companies are already mining landfills for valuable metals the previous generation junked in the 1970s. We must not set up the same dynamic by tossing away rare metal-laced gadgets.

One step to improving minor metal resource efficiency could be as simple as labeling. For people to begin to make educated decisions about their resource consumption, they need to know what they are consuming. Labeling also encourages companies to know what materials are in their products and can facilitate recycling when the information is placed in bar codes on the side of a product.

A report by the Ellen MacArthur Foundation states that a circular economy, based on remanufacturing, reuse, and recycling would save \$1 trillion in material costs by 2025 and create one million jobs in Europe alone. It could also fuel the next generation of recycling techniques, which the world desperately needs.

An even better way to keep minor metal resource use in check is decidedly low-tech: conservation. Energy conservation measures—such as improving the efficiency of energy grids, electronics, and buildings—reduce the need to build or expand infrastructure that relies on minor metals. For example, it's far less resource intensive to add extra insulation to reduce energy demand than to install a solar panel to produce more efficient energy; it's also a good way to consume fewer rare metals.

While the answer for resource security won't come solely from government capitals, the right legislation and regulatory changes can have a great influence. In addition to extending producer responsibility, providing greater funds for technological innovation and adopting energy conservation measures, governments should develop long-term plans to increase rare metal supply. A good start for countries with resources would be to clarify the time frame and review

process for new mining operations and specify the places that are off limits to exploration. With the length of time required to open a mine extending over a decade, governments should examine ways to speed up an environmentally sound development process. Wealthy governments should not outsource pollution.

Another role for government is to help produce and disseminate market data to solve market problems. This is a role that the U.S. Geological Survey helps to fill, although cuts in funding over the years have adversely affected the consistency of the information. Such research can help to identify gaps in supply and anticipate future trends. Governments should also work more closely with research institutions and the tech industry to better understand future demands for rare metals.

Governments can help to encourage production by offering tax incentives; subsidized insurance to reduce risks for mining investments; and by taking debt or equity stakes in companies. Less traditional incentives, such as purchasing agreements, can ensure production and investment during periods of volatile pricing. And for start-ups, government support and broad statements of policy support could be the boost needed to secure long-term investor funding. But most governments outside of Asia are less likely to “pick” winners.

Some studies argue that stockpiling rare metals is a key government policy tool to ensure material in times of shortages. However, stockpiling rare metals is unlikely to be successful because manufacturers need a variety of grades of material, making it nearly impossible to stock enough material in the right grades. What’s more, if a stockpiling country lacks processing facilities, stockpiling a rare metal is like stockpil-

ing cans of tuna without a can opener: well-intentioned, but useless. Stockpiling may well be very expensive because governments often buy when prices are high, forcing prices even higher.

What may be more useful, although less politically palatable, is for governments to set regulations or offer incentives for companies to stockpile the rare metals they require and the components made from them. Companies know what their needs are and therefore have an advantage over governments in choosing which materials to stockpile. However, companies are reticent to tie their cash up in resources that may fall in value.

Just as setting the right policy is crucial, avoiding hasty decisions is likewise important. After China restricted access to rare earths in 2010, Tokyo quickly made the strategic decision to reduce the country’s reliance on China’s rare earths, encouraging companies not to use materials from China. The Japanese looked prescient as the rare earth price skyrocketed through 2011. But the price quickly crashed because the spike was more related to geopolitics than to economics. And Japan’s plan began to backfire.

After an initial rush to stock up on rare earth elements, Japanese companies reduced their use of them dramatically and quickly, especially the light rare earths, the ones Japan used in copious amounts. In the following two years, when prices dropped, they likely fell far lower than they would have due to the dramatic reduction in Japan’s demand. The lower prices left many western rare earth companies struggling. Many of those companies may not last, which would, paradoxically, make Japan more reliant on China and set up long-term dependencies.

Tokyo’s hasty decision to help companies to shift from using rare earth elements also had another, more subtle effect. When companies followed government policies and reduced the amount of rare earths in their products, it led to less energy-efficient motors for products ranging from air conditioners to elevators. Although the loss in efficacy from switching to a less efficient magnet or different system may be small for each product, its effect is large when the world is buying, for example, air conditioners that are even just a few percent less efficient.

Governments need to let companies deal with the short-term vagaries of the market. The truth is that unless governments are willing to financially guarantee the development of an international supply chain of raw materials, and to continuously assess it, there is no way to ensure consistent supply. The only time governments should step in is to offer a short-term solution to avoid an economic collapse or to ensure that there are no gaps in a country’s military defense supply lines.

Countries can only do so much individually to improve resource security because supply lines are global. What’s more, while rare metal supply lines are unique, many of the strategies to ensure their viability are similar to the strategies for ensuring supply lines of other natural resources. For example, individual resource-dependent countries need to bolster political ties with neighbors, especially resource rich ones, as the United States did with Latin America in the first half of the twentieth century. Setting up trade missions and signing trade agreements to increase trade and investment in resources benefits the home country, but the additional production that would result will also benefit the world. Ultimately, however, just

as one country cannot dig itself to resource security the world cannot do so either. There is a role for working together.

To avoid future conflict, it would be useful to address rare metal supply concerns in a global forum. But since none exists, it's time to create one. After oil shortages in the early 1970s, sixteen countries founded the International Energy Agency (IEA) to ensure the uninterrupted flow of oil. The agency's mission expanded to "promote diversity, efficiency and flexibility within all energy sectors." We now need an International Materials Agency, an IEA for mineral resources, including rare metals.

It is critical to have an organization that collects statistics, writes market reports, and provides a forum for countries to discuss issues related to natural resources. An International Materials Agency with its own staff can develop strategies for best practices in managing resources. Dialogue and an attempt to make markets transparent is the best hope we have of preventing future re-

source conflicts. And a materials agency is a far more effective venue than the World Trade Organization for hashing out disagreements.

Rare earth magnet manufacturers now use lower amounts of rare earths, including dysprosium, in their magnets than in 2010 when China cut exports to Japan. Part of the reason is that companies have become better at using dysprosium selectively. Other companies have found that adding terbium, a rare earth element produced only in China, can help reduce the need for dysprosium.

When I ask Masato Sagawa [inventor of a strong, permanent magnet that requires no cobalt or samarium] about the switch from dysprosium to terbium, he warns me, "The scarcity of terbium will become much more serious than for dysprosium." He adds that using terbium, which is four times less abundant than dysprosium, is a temporary move. But adding terbium reminds me of a similar decision thirty years ago when he [Sagawa] added dysprosium to his magnet recipe. Companies may be able to

reduce the amount of terbium and dysprosium in magnets by 20–30 percent over a five-year period, but the growth rate of magnets over the same period may well exceed 50 percent or more. This means that despite using these rare earth elements in smaller quantities per magnet, our total demand for rare earths will rise.

We are now at a critical moment. The speed of technological change will soon outpace the ability of our supply lines to produce rare metals at the prices demanded. Meeting this growing demand for rare metals requires profound changes in how we use and sell our products. My fear is that a lack of attention to and understanding of this new dynamic in the Rare Metal Age, as well as a lack of attention and understanding in regard to these critical materials, will limit our prosperity and undermine our environment. My hope is that my book in some measure will serve as a rallying call to inspire a new generation to learn about the ingredients of our gadgets, guns, and sustainable future.

A Flood of Choices: Considering Privatization of Water Utilities

Daniel J. Van Abs

Municipalities with publicly-owned water systems, whether for drinking water or sewage, face a fundamental choice every day—retain control, contract for management (public-private partnerships, or PPP), or sell (full privatization). These government utilities are municipal utilities, operated as municipal departments, or municipal utility authorities (MUAs) serving one or more towns.

If the municipality keeps control or contracts out, they retain options to make a different decision later. The decision to sell is essentially permanent. In every case, the choice should not be made absent hard, public analysis.

What are the Critical Factors for Consideration?

Two major questions should be answered. First, why change from public management? Second, what should be gained from private management?

We should be very clear in our understanding of one point. These decisions have nothing to do with who owns the water, and what operational standards

must be met. The law is very clear—water resources of New Jersey are owned by the public and are managed on the public's behalf and in their behalf by the State of New Jersey. The drinking water and wastewater treatment quality standards are all the same regardless of ownership, as are construction standards.

So what really changes with ownership? The major changes may include:

1. The burden of management
2. The capabilities of the utility
3. The source and use of utility funds
4. Rate implications

Let's look at each of these changes in light of the two questions noted previously.

The Burden of Management

New Jersey has more public community water supply utilities than municipalities. Some are small private companies, such as for mobile home parks. Others are large investor-owned utilities. Many are municipal utilities or MUAs. We have fewer public sewerage entities, nearly all of them government-owned.

Regardless of municipal administration, the work of a municipal utility is overseen by the municipal governing body, few of which have real expertise in utilities. When all is going well, the tendency is to focus on more familiar municipal priorities, such as police. When things go bad or a major rate increase looms, it is understandable that

elected officials seek ways to outsource management. The smaller the municipality, the more likely this is to be true.

This is one reason we have municipal utility authorities (MUAs), which have appointed boards that can become familiar with utility issues. The MUA board can hire expertise to run the utility. The appointment process keeps the board "under the thumb" of the elected officials. This system works well as long as no major issues slop over into the political realm. Unfortunately, major rate increases, declining service quality, conflicts over service extensions, and a desire to monetize utility assets bring MUAs into trouble with elected officials. The result again is that elected officials may opt for private management. In this case, both small municipalities and cash-starved ones (regardless of size) may be tempted to act.

What might they want to achieve through a PPP or sale? First, to be relieved of a responsibility that is complex, costly and diverting them from other major public priorities. Second, to limit or eliminate public liability for future costs. Third, to shift control to those perceived to have greater expertise, access to capital, or flexibility.

The Capabilities of the Utility

Major players in the public and private sectors have told me that a water utility of sufficient size can be operated in a competent, cost-effective manner under public ownership. The simpler the system, the smaller that "sufficient size" will be. Unfortunately, what is possible doesn't always happen.

Van Abs is an associate professor of practice for water, society and environment at Rutgers University. This article is adapted from an article that appeared in a 2016 issue of New Jersey Municipalities, the New Jersey League of Municipalities' magazine. The views in the article are his and have not been reviewed or endorsed by Rutgers.

It is reasonable that larger organizations will have greater capabilities, as they are sufficiently complex to justify and afford staff with greater expertise. However, most large water utilities in New Jersey are investor-owned companies. Government utilities generally avoid mergers, acquisitions, public-public partnerships and the like. They remain static while the private sector grows.

The desire for enhanced capabilities might drive elected officials toward private sector involvement. They generally neglect to investigate similar public sector opportunities, or give up due to lack of willing partners.

The Source and Uses of Utility Funds

Municipal utilities and MUAs may receive their funding from customers (through rates), from the municipal *ad valorem* tax (paid to the utility through

the local budget), or both. Municipal utility and MUA revenues should serve utility purposes. However, under existing law municipalities may divert some revenues for other municipal purposes. Some do, some don't.

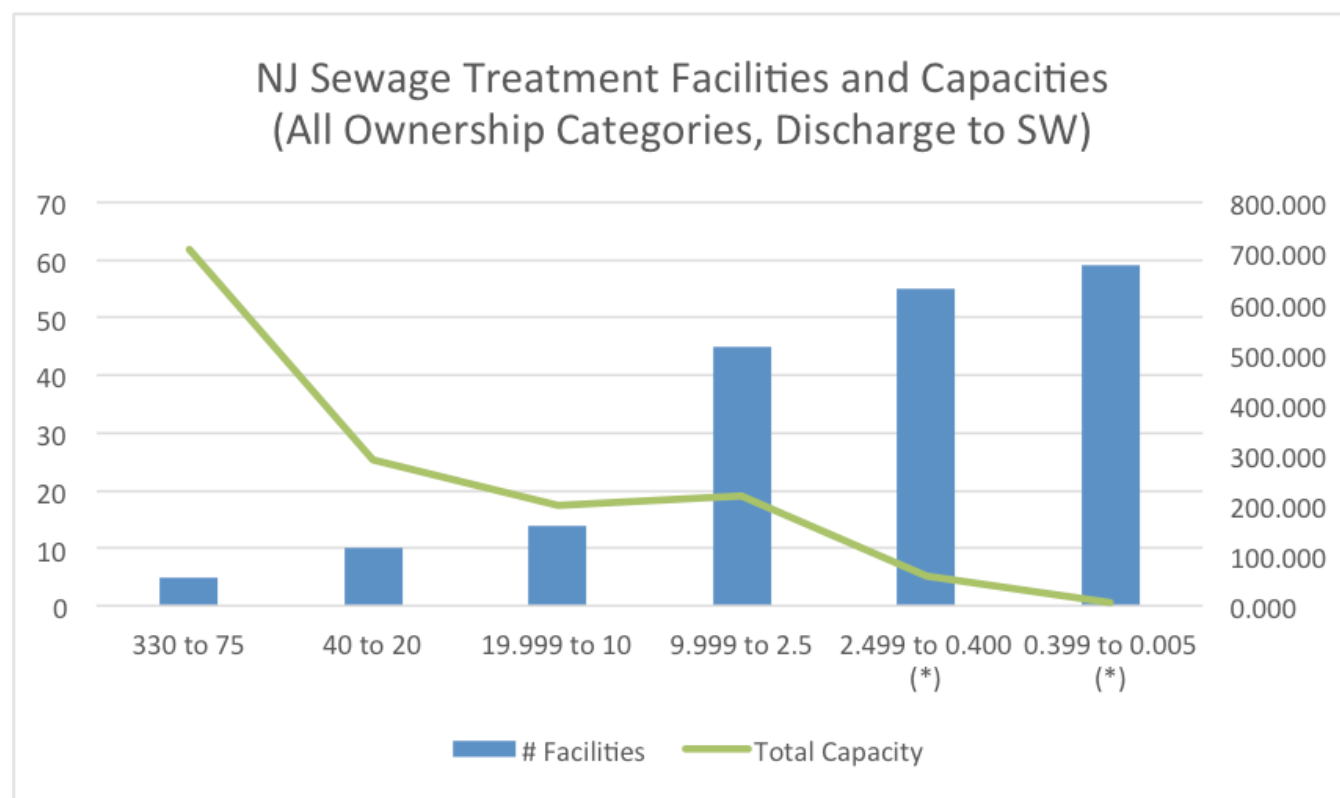
PPP firms get their funding through the contract. Going to a PPP contract may increase utility revenues through better collections, but may decrease revenues to the municipality by redefining what can be diverted. A private utility gets its funding from the ratepayers. Both PPP contracts and outright sales often come with upfront cash payments that benefit taxpayers by offsetting property tax revenue needs for a year or so, but are paid for by utility customers through rates long term.

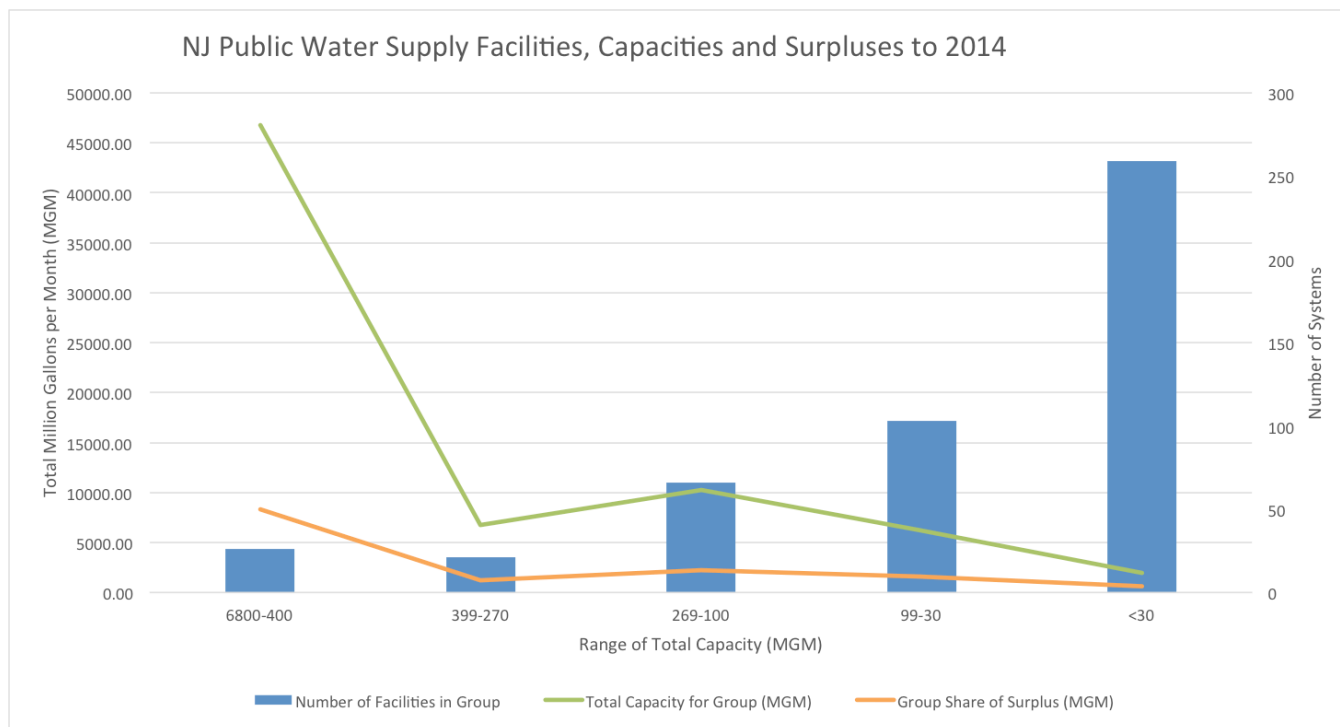
A recent state law reduces oversight of these payments. All in all, that seems like a bad deal for ratepayers, but elected officials may see the funding as a boon that helps get them through another bad budget year.

Rate Implications

Some interests oppose private ownership of water utilities, in part because of the profit motive. As noted above, elected officials can also find ways for government utilities to provide a "profit" but in this case it benefits taxpayers at the expense of ratepayers, who are not necessarily the same entities.

What the elected officials may hope for, especially in the case of a PPP, is that the private company will be able to reduce costs sufficiently to allow for their profit margin without a significant increase in rates. The rates are often specified in the PPP contract. However, those contracts also generally make the municipality responsible for major capital costs, either entirely or beyond a fixed amount in the contract. So while one part of the rate may be fixed, another critical part is not – and that part is highly likely to grow as our infrastructure ages and crumbles. For a sale, the rates





become the problem of the Board of Public Utilities, and the municipal officials are off the hook.

So, Does Privatization Cost More?

The best response: To whom and for what? My team at Rutgers was unable to find a statewide inventory of water utility rates, and so compiled 2013 drinking water and sewer rates in municipalities with combined sewer systems, for a New Jersey Future study. For a nominal household in municipalities with combined sewer systems use of 60,000 gallons per year, annual average drinking water costs \$380. For investor-owned drinking water systems, the average annual cost for the utilities was \$424, 11.6 percent higher. None of the sewer systems were investor-owned utilities.

The problem with comparing rates is that we have no real sense of how well maintained each system might be. Are investor-owned rates higher because of greater capital investments, higher financing costs, or profit margins? The

latter two can be determined, but the first one requires an understanding of the overall capital needs for both the government-owned and investor-owned systems, which are not generally available.

The problem with comparing rates is that we don't really know what we are comparing. The entire debate degrades into unsupportable claims. Therefore, municipalities are likely to use the four issues above as their benchmarks for decision-making.

Well-run systems in financially sound municipalities are unlikely to be privatized—the problems that drive change don't exist, and so inertia will win. Problematic utilities, or those in fiscally-strained municipalities, offer perceived benefits. PPP contracts offload responsibility and gain short-term cash. For sales, negotiations set the price even though the utility may not have much real net worth (assets minus liabilities).

BPU and the Ratepayer Advocate no longer have much leverage to ensure a fair price, and so the costs probably will

be folded into the broader rate structure of the private company. The result is that the rates of many people go up a little, and the rates of a few people could drop significantly. It's a local political win, but a societal loss.

Final Thoughts

My conclusions include several points:

- Public enterprises should be able to match private sector capabilities but are too often constrained from doing so.
- Privatization can be a valid approach, but is certainly no panacea.
- Privatization is seen as a method to outsource problematic issues.

Finally, we lack the information to credibly compare the costs of public and private ownership, in part, because we lack decision-making systems that require analysis before action.

The Case for Cosmetic Safety Reform

Scott Faber

Each day, American women use an average of 12 personal care products that contain 168 different chemicals. Men use an average of 6 personal care products that contain 85 different chemicals. Few consumer products contribute as many exposures to chemicals as cosmetics and other personal care products.

Under current law, however, the Food and Drug Administration has no duty to review the safety of these chemicals. While most cosmetic chemicals likely pose little or no risk to human health, exposure to some chemicals used in cosmetics and other personal care products has been linked to serious health problems, including cancer and reproductive harm. Chemicals found in cosmetics and other personal care products that have been linked to health problems include phthalates, parabens, methylisothiazolinone, lead acetate, triphenyl phosphate, and formaldehyde and chemicals designed to release formaldehyde. Some chemicals pose risks at low doses. In addition to risks

posed to consumers, hair and nail salon workers are especially susceptible to cosmetic chemical exposures.

Certain cosmetic chemicals can interfere with the hormone system, and some of these “endocrine-disrupting” chemicals are found in personal care products. Chemicals like phthalates and triphenyl phosphate can disrupt the hormone

*Under current law, the
FDA has little
authority to review or
restrict chemicals in
cosmetics
[and personal care
products.]*

system by mimicking or blocking a natural hormone. When an endocrine-disrupting chemical mimics a hormone, the chemical tricks the hormone’s receptor into thinking the chemical is the hormone. When the chemical blocks a hormone, the chemical can bind to a receptor and the hormone may not be activated.

Endocrine-disrupting chemicals pose unique risks to vulnerable populations, such as pregnant women and infants, where the impacts may take years to become apparent. Research shows that endocrine-disrupting chemicals may pose the greatest risk during prenatal and early postnatal development, when organ and neural systems are forming. Expo-

sure to these chemicals has been linked to endocrine diseases including diabetes and some types of cancer.

Some chemicals in cosmetics and other personal care products also pose acute risks. Formaldehyde-based hair straightening procedures, referred to as “keratin treatments,” have been linked to hair loss, rashes, blisters, nosebleeds, bleeding gums, and loss of taste and smell. Thousands of women and girls recently reported losing some or all of their hair after using a shampoo promoted by a celebrity hair stylist. Some skin lightening creams contain mercury. If produced in unsanitary conditions, products can become contaminated with bacteria and mold—including shampoos, shower gels, makeup, and mouthwash—and cause serious harm, including infections. For example, two baby wipe companies recently manufactured products contaminated with bacteria.

Under current law, the FDA has little authority to review or restrict chemicals in cosmetics. In general, substances used in cosmetics and other personal care products are not subject to review or regulation by FDA and few have been restricted. FDA can only restrict chemicals that render the product “adulterated,” and FDA has only banned or restricted nine ingredients under this authority. Only products that pose acute risks, such as contaminated products, are “adulterated” and the FDA must work with the Department of Justice to demonstrate that a product meets this test. By contrast, many chemicals in cosmetics have been restricted by our trading partners in Canada, Japan, and

Faber is the senior vice president for governmental affairs for Environmental Working Group. This article is adapted from his testimony on exploring current practices in cosmetics development and safety before the Senate Committee on Health, Education, Labor and Pensions on September 22, 2016. His complete testimony is available at <http://www.ewg.org/testimony-official-correspondence/ewg-testimony-exploring-current-practices-cosmetics-development>.

the European Union. For example, the use of certain parabens linked to hormone disruption is restricted in the European Union—especially in products for use by infants—but there are no such restrictions in the United States.

By contrast, other agencies—and even other branches of the FDA—have broad authority to review and regulate other chemicals found in consumer products. For example, FDA has the authority to review chemicals in prescription and over-the-counter drugs and chemicals found in food. The Environmental Protection Agency (EPA) has the authority to review chemicals in pesticides used in our homes and on farms and to set limits for pesticide residues on food. This year, Congress expanded EPA authority to review chemicals in cleaners, paints, solvents, and many other consumer products. The Consumer Product Safety Commission (CPSC) has the authority to develop standards and bans for many consumer products. Updates to the Consumer Product Safety Act gave CPSC specific authority to set content limits for lead in children's products, paint, and electronic devices, promulgate standards for durable infant or toddler products, limit toxic substances in toys, and ban certain phthalates in children's products.

FDA and other agencies also have broad authority to collect data on chemicals found in consumer products. When FDA reviews food chemicals, for example, FDA requires the submission of certain safety and use data. EPA also has broad authority to require safety data on chemicals used in industrial and consumer products. This year, Congress gave EPA broader authority to obtain new information about chemicals. For pesticides, EPA has guidelines specifying what kind of data must be included with a pesticide registration. The CPSC has specific authority to require any manufacturer of a consumer product to submit data.

Why has Congress failed to give FDA the power to review the safety of cosmetic chemicals? One reason is that industry has argued that self-regulation is adequate to ensure safety. But, unlike industry-financed review programs, government regulatory programs are governed by minimum standards for collection and review of chemical exposure and toxicity data. These self-regulatory programs lack the same access to data about chemical use and toxicity as government regulators. As a result, these bodies often fill gaps in data by assuming very large groups of structurally-similar chemicals have the same impacts on human health. What's more, cosmetic formulators have no obligation to abide by self-regulatory program recommendations, and these recommendations frequently lack specific limits or instructions on chemical use, manufacture, or processing.

Self-regulatory bodies may downplay long-term health risks in favor of short-term risks. In general, self-regulatory programs tend to focus on short-term effects, such as allergic reactions, and lack the capacity to review health impacts from chronic exposures. Substances such as endocrine-disrupting chemicals may cause health effects that will not be apparent for many years. In addition, some self-regulatory panels incorrectly assume that exposures to chemicals in cosmetics are too low to impact health. For example, some panels have improperly asserted that exposures via routes such as inhalation cannot occur.

As a result, some findings by industry self-regulatory bodies are inconsistent with the findings by other regulatory authorities or experts. For example, methylisothiazolinone, iodopropynyl butylcarbamate, and methyltribromoglutaronitrile—preservatives deemed too risky for certain uses by government regulators—were found safe for use by industry panels at higher concentrations

or without similar restrictions. Two hair dye chemicals that have been linked to health problems by Canadian regulators and the National Toxicology Program (NTP), respectively, have been deemed “safe as used” as well. Another chemical is used in fragrance without restriction, even though an NTP study found it is a likely carcinogen.

It's also important to recognize that consumers expect that government, not industry, has reviewed the safety of personal care products. Recent polling conducted by American Viewpoint and the Mellman Group found that two-thirds of consumers believe chemicals in cosmetics are *already* reviewed by the FDA. Three-fourths of consumers—regardless of age, race or party affiliation—support stricter regulation of chemicals in cosmetics and nearly nine-in-ten consider stricter rules very important. In addition, nine-in-ten consumers believe cosmetic companies should have to notify FDA if their products harm consumers, support giving FDA mandatory recall authority, and support rules that ensure cosmetics are produced in a clean environment.

Despite these expectations, FDA lacks the basic tools needed to ensure the safety of cosmetics and other personal care products. Under current law, cosmetic companies do not have to register with FDA, submit cosmetic ingredient statements, adopt good manufacturing practices, provide access to safety records, report adverse events, or share the cost of a modern regulatory system. FDA also lacks the authority to quickly suspend production or recall contaminated products when a company fails to initiate a voluntary recall.

By contrast, food, drug and device manufacturers must register their facilities with FDA; maintain and give FDA access to records; and report any adverse events to FDA. Drugs, devices, and biologics cannot be sold without prior FDA approval, including approval

of a product's ingredients. If food, drugs or devices are unsafe, FDA can suspend production and product licenses. When unsafe food, drugs, and devices do reach the market, FDA can order recalls of food, biologics, and devices and can take legal action against drug makers who do not recall their products.

In the absence of meaningful federal regulation, non-federal actors have begun to review and, effectively, regulate some cosmetic chemicals. In particular, several states have enacted chemical safety review programs that cover cosmetic chemicals and have taken steps to limit the use of particular cosmetic chemicals. Some retailers have developed lists of chemicals that cannot be used in products, and some non-governmental organizations have developed tools to rank the safety of cosmetics. In response, many cosmetic companies have finally concluded that a law enacted in 1938 to prohibit the use of "filthy, putrid, or decomposed" substances is woefully out of date.

As a result, many cosmetic companies and public health organizations have supported Congressional efforts to create a modern regulatory program for cosmetics and other personal care products, as proposed in the Personal Care Product Safety Act. A modern regulatory program would give FDA the power to review cosmetic chemicals of concern, expand FDA's ability to know when contaminated products threaten public health, give FDA the resources to detect and respond to threats to public health, and grant FDA the power to act when companies decline to voluntarily recall contaminated products.

In particular, FDA should have the power to review and regulate cosmetic

chemicals to ensure that these chemicals pose a reasonable certainty of no harm to human health. Once chemicals of concern have been identified, FDA should quickly collect data on chemical use and toxicity to determine whether the chemical is safe or should be subject to restrictions.

Although dangerous cosmetic chemicals should be subject to FDA review and regulation, industry review pro-

*Two-thirds of
consumers believe
chemicals in cosmetics
are already reviewed
by the FDA.*

grams should also be strengthened. In particular, cosmetics law should clarify the role of industry self-regulatory programs and clearly establish the duty of cosmetic companies to substantiate the safety of their products. Industry-financed programs that are not based upon widely-accepted scientific principles should not be the basis upon which companies can claim that personal care products are safe.

Finally, cosmetics law should place the same duties on cosmetics companies as federal law now places on other FDA-regulated industries. In particular, cosmetic companies should be required to register with FDA, provide FDA with cosmetic ingredient statements, and should be required to provide FDA access to safety records. To prevent microbial contamination, cosmetic companies should be required to adopt good

manufacturing practices that will ensure that cosmetics are produced in a safe and clean environment.

In addition, cosmetic companies should be required to quickly report serious adverse events and to frequently provide FDA with all adverse event reports. If a contaminated product poses serious health risks and a company has declined to conduct a voluntary recall, FDA should have the power to order a mandatory recall and to suspend production of contaminated products.

Cosmetic companies should also be required to provide consumers more information about cosmetic chemicals, including fragrance ingredients. Any disclosures required for cosmetics and other personal care products should apply to sales of salon products and to sales made through internet retailers.

All of these reforms have been endorsed by the personal care products industry, including large and small manufacturers. These are reasonable and familiar reforms that will boost consumer confidence in the safety of cosmetics and other personal care products and ensure that these essential, everyday products are safe.

Editor's note: *The Environmental Working Group maintains a database of chemical assessments of 1000s of cosmetic and personal care products known as "Skin Deep." Skin Deep was launched in 2004 to fill in where industry and government leave off. For more information, visit: <http://www.ewg.org/skindeep/>.*

Implications for U.S. National Security of Anticipated Climate Change

U.S. National Intelligence Council

Foreword

This memorandum was prepared by the National Intelligence Council and was coordinated with the U.S. Intelligence Community (IC).

In the Intelligence Community's analysis of the possible impacts of climate change on national security over the next 20 years, the IC takes as a scientific baseline the reports produced by the Intergovernmental Panel on Climate Change (IPCC), the international body responsible for assessing the science related to climate change. This memorandum does not assess effects on the homeland, nor does it evaluate the science of the IPCC reports.

Climate change is projected to produce more intense and frequent extreme weather events, multiple weather disturbances, along with broader climatological effects, such as sea level rise. These are almost certain to have significant direct and indirect social, economic, political, and security implications during the next 20 years. These effects will be especially pronounced as populations

continue to concentrate in climate-vulnerable locales such as coastal areas, water-stressed regions, and ever-growing cities. These effects are likely to pose significant national security challenges for the United States over the next two decades, though models fore-

Climate change is projected to produce more intense and frequent extreme weather events.

cast the most dramatic effects further into the future. While specific extreme weather events remain difficult to attribute entirely to climate change, unusual patterns of extreme and record-breaking weather events are likely to become more common, according to the IPCC.

Extreme weather events, such as heavy rainfalls, floods, droughts, cyclones, and heatwaves, will disrupt critical human and natural systems. They could trigger crop failures, wildfires, energy blackouts, infrastructure breakdown, or infectious disease outbreaks. The frequency and magnitude of such events are increasing as the climate changes, according to the IPCC.

Moreover, multiple weather disturbances—when several extreme weather

events occur within a small region or short time—compound their impact while undercutting efforts by people and governments to cope. Clusters or rapid sequences of relatively modest weather events may cause more damage than very powerful single events.

Global climatological stresses—such as sea-level rise, ocean acidification, permafrost and glacial melt, air quality degradation, changes in cloud cover, and sustained shifts in temperature and precipitation—could substantially alter broader natural and manmade systems involving where and how humans live and patterns of infectious disease outbreaks, as well as critical ecosystems.

The table on the following page lays out the IPCC baseline for likely increases in extreme weather events in the decades ahead. Such events may occur at different rates of frequency, intensity, and location compared to historical patterns, and lack of preparedness for those changes—such as weather-related disasters, drought, famine, supply chain breakdown, or damage to infrastructure—may prove a primary cause of disruption.

Effects of Climate Change on National Security: Possible Pathways

Climate and weather have long affected the national security of countries worldwide, although most often as a contributing factor that might be recognized only in retrospect. Sometimes the

This article is adapted from a 2016 memorandum by the National Intelligence Council. The complete memorandum is available at <https://www.dni.gov/index.php/newsroom/reports-and-publications/214-reports-publications-2016/1415-implications-for-us-national-security-of-anticipated-climate-change>.

Projected Trends in Extreme Weather Events

Phenomenon	Likelihood of Changes in 2016-2035	Likelihood of Changes by 2080-2100
Warmer days and nights	Likely	Virtually certain (99-100%)
More hot days and nights	Likely	Virtually certain
More warm spells and heatwaves	Likely	Very likely (90-100%)
More heavy precipitation events	Likely	Very likely
More droughts	More likely than not	Likely (66-100%)
More intense tropical cyclones	More likely than not	More likely than not (33-66%)
More extreme sea levels	Likely	Very likely

Source: Intergovernmental Panel on Climate Change, Fifth Assessment Report, September 2013

effects are dramatic—such as the brutal Russian winter that contributed to Hitler’s failed invasion in World War II—but more often weather and climate exert indirect effects that shape underlying social, political, and economic conditions. Academic research on the impacts of climate on political and security outcomes is still sparse, but we judge that climate will affect U.S. national security interests over the next 20 years through the following pathways.

Threats to the Stability of Countries

Many countries will encounter climate-induced disruptions—such as weather-related disasters, drought, famine, or damage to infrastructure—that stress their capacity to respond, cope with, or adapt. Climate-related impacts will also contribute to increased migration, which can be particularly disruptive if, for example, demand for food and shelter outstrips the resources

available to assist those in need.

When climate-related effects overwhelm a state’s capacity to respond or recover, its authority can be so undermined as to lead to large-scale political instability. Countries with weak political institutions, poor economic conditions, or where other risk factors for political strife are already present will be the most vulnerable to climate-linked instability. In the most dramatic cases, state authority may collapse partially or entirely. Climate-related instability is likely to create strong pressure for foreign aid, disaster assistance, or military responses. Even if climate-related disruptions do not undermine stability, however, some governments could be so preoccupied with managing the effects that they have little time or energy left to engage on broader foreign policy issues.

Fueled by unusually warm Arabian Sea waters, two separate tropical cyclones hit Yemen in 2015 in the span of just 10 days, including the first

hurricane-strength storm to hit the country in recorded history. Already suffering a humanitarian crisis from war and water shortages, Yemen was unable to provide adequate relief for its citizenry. Heavy rains have since fueled the breeding of an unusually large population of desert locusts that threaten to devastate Yemen’s agriculture, and efforts to eradicate the locusts have been stymied both by the difficult security situation and by fear of killing bees, a crucial pollinator for the region’s honey and crop production.

Heightened Social and Political Tensions

Decreases in water and disputes over access to arable land will increase the risk of conflict between people who share river basins, aquifers, or land areas. Although historically water disputes between states have led to more water-sharing agreements than violent conflicts, according to academic

studies, we judge that this trend could change over the next 20 years as water scarcity and variability intensify, possibly leading to disputes that pose greater challenges to security. Although environmental stress is rarely the sole cause, disputes between groups within countries over land and water resources are increasingly common as triggers for social violence and internal conflict, particularly when social and political tensions already exist.

In 2014, citizens in a village on the outskirts of Mexico City, already water-stressed by drought, battled antiriot police during a protest over the diversion of spring water to a new development nearby. More than 100 police were injured, many seriously.

In 2014, farmers and herdsman in Nigeria clashed over access to grazing land and dwindling well water. Then President Goodluck Jonathan ordered military operations to reduce the violence.

In 2012, mass protests and violence erupted over water shortages in Nouakchott, Mauritania. More than 70,000 refugees had migrated to Mauritania by July that year because of deteriorating conditions in neighboring Mali, putting additional pressure on Mauritania's water and soil resources, already strained by drought and desertification.

Even if climate-induced environmental stresses do not lead to conflict, they are likely to contribute to migrations that exacerbate social and political tensions, some of which could overwhelm host governments and populations. Sudden extreme weather—such as from floods, droughts, and severe tropical storms—almost certainly will increase the number of displaced people, particularly in regions that are unaccustomed to or unprepared for such events. Rising sea levels and unexpectedly large storm surges could threaten small island states and low-lying coastal regions—including many megacities—with flooding and saltwater contamination of fresh-

water. Over 20 years, the net effects of climate change on the patterns of global human movement and statelessness could be dramatic, perhaps unprecedented. If unanticipated, they could overwhelm government infrastructure and resources, and threaten the social fabric of communities.

The Arctic region is warming twice as fast as the rest of the planet, transforming rapidly, according to the National Oceanic and Atmospheric Administration. The resulting retreat of sea ice is creating new possibilities for resource extraction, tourism, fishing, and shipping routes between the Atlantic and

*More frequent extreme
weather events,
ranging from droughts
to extreme rainfall,
would significantly
threaten agricultural
production.*

Pacific. Unpredictable ice floes, remoteness, and harsh conditions will limit operations in the Arctic over the coming decade, but disputes over unresolved maritime boundary claims, military posturing, and economic activity could increase as the Arctic opens.

Contention over Russia's claim to 1.2 million square kilometers of Arctic shelf, which Moscow submitted to the UN in August 2015, could increase friction with rival claimants, including Denmark and Canada.

Opening waterways have encouraged a Western cruise line to plan the first month-long cruise through the Northwest Passage this summer, carrying more than 1,000 passengers. Maritime authorities have cautioned that the voyage is high-risk in terms of navigational

security and because of limited search and rescue capabilities.

Significant thawing of Arctic and sub-Arctic permafrost could rupture the China–Russia crude oil pipeline—an important shared resource between the two countries—and could threaten the integrity of other Russian pipelines, according to recent scientific studies.

Political disputes could arise over climate change responses and policies. Some adversely affected countries may seek relief through international judicial mechanisms. Countries not meeting their pledges to reduce carbon emissions may face heightened political pressure and eventually punitive actions—such as sanctions or pricing carbon into trade—even though the pledges now are voluntary, with no current enforcement mechanism.

Unilateral efforts by countries or groups to test or deploy geoengineering—a largely theoretical field exploring how the climate might be modified intentionally through methods such as injecting aerosols into the stratosphere or chemically changing the reflectivity of clouds—would almost certainly heighten regional or international tensions, especially in the absence of multilateral frameworks or institutions to govern such activities. Some forms of geoengineering experimentation are probably within the financial and technical capacity of some major powers and individuals, although there are fundamental scientific uncertainties about the efficacy and possible unintended consequences of such methods.

If, for example, geoengineering methods suppressed global temperatures below the point assumed to bring dangerous climate change, such efforts would almost certainly need to be sustained and probably would alter global weather patterns, benefitting some regions at the expense of others, according to the National Academy of Sciences.

Adverse Effects on Food Prices or Availability

More frequent extreme weather events, ranging from droughts to extreme rainfall, would significantly threaten agricultural production. Moreover, long-term climate trends—such as more very hot days, changing precipitation patterns, and poleward shifts of tropical clouds—along with constraints on land, water, and energy also put upward pressure on food prices. We judge that in countries with weak political institutions, climate-induced threats to food security sharpen the risk of social disruption, migration, or large-scale political instability.

The terrorist group Al-Shabaab ex-

ploited the 2011-13 famine in Somalia to coerce and tax international aid agencies, and it withheld food from those it deemed uncooperative, according to Human Rights Watch.

In 2015, insurgent groups in northern Mali exploited deepening desertification, worsened by persistent drought, to enlist locals in a “food for jihad” arrangement.

Heatwaves threaten livestock directly and also reduce fertility, decrease milk production, and make them more vulnerable to disease. Droughts, wildfires, and extended periods of reduced precipitation threaten pasture and food supplies, indirectly threatening livestock.

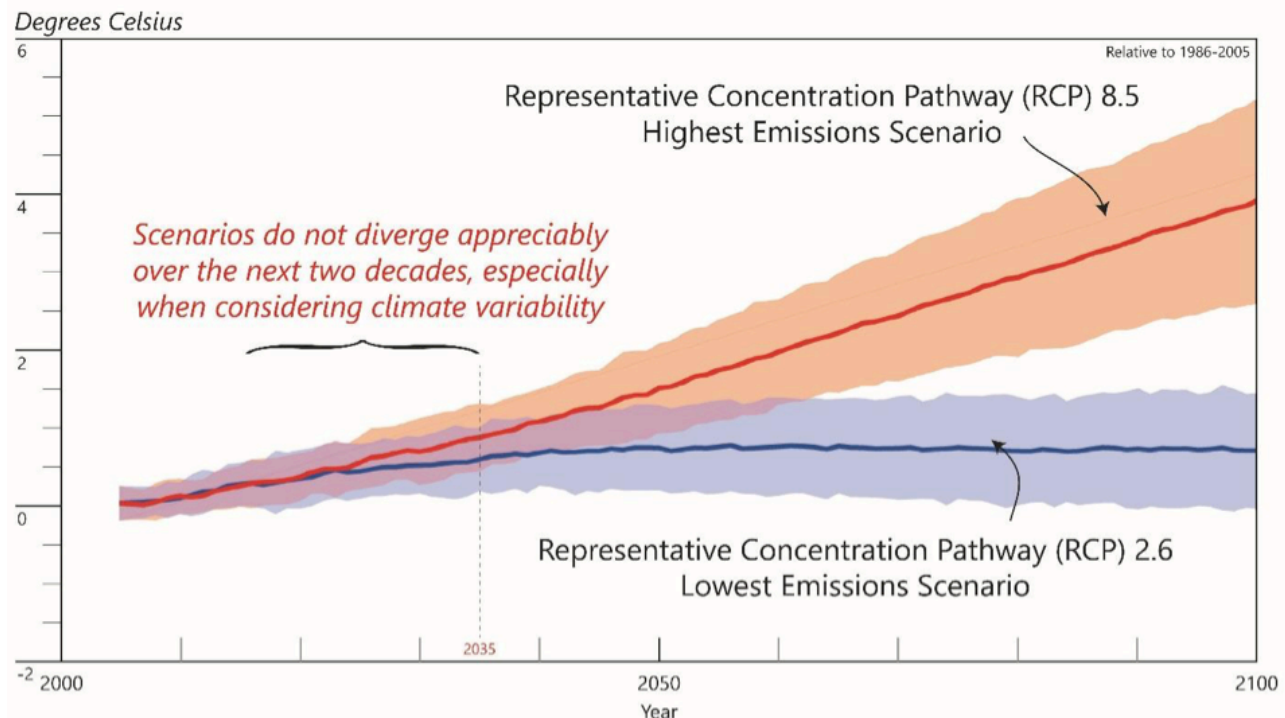
In Australia, the world’s third-largest beef exporter, the direct and indirect im-

pacts of heatwaves have contributed heavily to a decline in cattle stocks to the lowest levels in 20 years.

Increased ocean temperatures and more frequent and more intense storms will increasingly threaten fisheries, many of which are already under stress from overfishing and pollution, according to the UN Food and Agriculture Organization. As oceans become more acidic as they absorb atmospheric carbon dioxide, ecosystems on which fish and other sea life depend are further jeopardized.

Warm ocean temperatures have helped fuel an unprecedented, ongoing bloom of toxic red algae along the southern coastline of Chile since early May 2016. The damage to Chile’s important

Projected Average Surface Temperature Change



The bold curves represent averages in global surface temperatures determined from computer modeling, but the actual trajectory will have many peaks (higher than average) and valleys (lower than average). The peaks are qualitatively important because they likely represent snapshots of future average climate conditions.

Source: Intergovernmental Panel on Climate Change, Fifth Assessment Report, September 2013.

aquaculture industry has sparked protests from fishermen, who have blocked access to ports over what they view as inadequate governmental compensation for their losses.

Increased Risks to Human Health

Extreme heat increasingly will contribute directly to deaths from cardiovascular and respiratory disease across the globe, particularly among the elderly, according to the U.S. National Institutes of Health. High temperatures also raise the level of ozone and other air pollutants that exacerbate cardiovascular and respiratory disease. Rising sea levels and severe weather events will increasingly threaten medical infrastructure and other essential services, according to the UN World Health Organization.

The 2003 heatwave in Europe fueled their hottest summer on record since at least 1540, and contributed to more than 70,000 deaths, according to a peer-reviewed study by the French Institute of Health and Medical Research. Western Russia's most extreme heatwave in recorded history was in 2010, causing more than 11,000 deaths in Moscow alone, according to scientists.

Heatwave-related deaths in South Asia in 2015 numbered 2,500 in India and more than 100 in Pakistan. Another intense heatwave beginning in April 2016 produced India's highest temperature ever recorded (124°F) and has caused more than 400 deaths so far.

Higher temperature and, in some regions, more rainfall and flooding are likely to increase the frequency of water-borne diseases and diseases transmitted by insects, snails, and other cold blooded animals in those areas. Extended transmission seasons of important vector-borne diseases are expected across a potentially larger geographic range, according to the National Institutes of Health.

For instance, the mosquito *Aedes albopictus*, which is capable of transmit-

ting a broad range of viruses to humans, is likely to live longer in Western and Central Europe in the next few decades because of increasing temperatures, according to academic research. In contrast, projected changes on the Mediterranean coast of Spain are likely to diminish mosquito survival in that region.

The *Vibrio cholerae* bacterium, which causes cholera, thrives in warm, salty waters. Higher surface-water temperatures and rising sea levels could introduce cholera to previously unaffected areas.

Over 20 years, the net effects of climate change on the patterns of global human movement and statelessness could be dramatic, perhaps unprecedented.

Stress on Military Operations and Basing

Globally, more frequent and intense natural disasters will strain the capacity of U.S. and allied armed forces to deliver humanitarian assistance and disaster relief. The U.S. military may be called upon more frequently to respond to foreign crises if its counterparts in affected countries are overstretched, unable to handle their own crises or those in their neighborhood.

We also judge that rising sea levels, flooding, droughts, higher temperatures, and more frequent extreme weather events will increasingly threaten military capabilities and facilities on both U.S. and foreign territory, including military bases and training ranges.

Continued reduction of sea ice will increase the importance of the Arctic as a domain for military access and operations, although the environment there will remain challenging and unpredictable.

Implications for Investments and Economic Competitiveness

Past and anticipated extreme weather events may discourage investment in regions deemed particularly vulnerable. Infrastructure will be increasingly threatened by more extreme conditions in the near future, and freshwater from aquifers will be increasingly jeopardized by saltwater intrusion. Expectations of future losses will almost certainly increase insurance premiums and payouts, and insurance rates may increase well before real effects are felt in regions deemed vulnerable.

The chairman of Lloyd's of London, one of the world's largest and most influential insurance markets, has stated that climate change is its primary concern. Allianz, Europe's largest insurer, has said that climate-change-driven losses from extreme events could increase by 37 percent within a decade.

The financial burden of responding to emergent climate trends and severe weather events, including the cost of efforts to mitigate greenhouse gas emissions, will reduce financing available for other investments, except in cases where those climate investments lead to green-growth opportunities. Increasing heat stress is likely to adversely affect agriculture, manufacturing, and other sectors requiring physical labor and could significantly contribute to GDP loss.

Low-income countries are less equipped to rebound from the economic setbacks caused by extreme weather events, and an increase in the frequency of these events could contribute to or even push some people into poverty.

Potential Climate Discontinuities and Secondary Surprises

While current climate models project long-term increases in global average surface temperatures, climate scientists warn that more sudden, dramatic shifts could be possible, given the complexity of the system and analogs in the climate record. Looking back over the past 100,000 years, the earth's climate periodically has undergone extreme shifts, sometimes in as little as a decade. Such abrupt swings can occur in complex systems when seemingly small shifts in the forces in play suddenly trigger dramatic nonlinear change, such as when a slight drop in temperature can suddenly turn water into ice. A body of scientific research indicates that the current rate of increase of carbon dioxide in the atmosphere is the highest in perhaps as long as 66 million years, sea levels are rising faster than in the past 2,700 years, and the oceans are acidifying more rapidly than in the past 56 million years.

Many climate scientists warn that the risk of abrupt climate change—currently low—will increase over the next several decades and beyond. We judge that the possibility of abrupt climate change cannot be discounted over any timeframe because research has not identified indicators to forecast potential tipping points and other thresholds. Even if sudden shifts in the climate do not materialize, gradual shifts in climate could nonetheless spark surprising secondary effects—such as a massive release of gases from melting permafrost, persis-

tent megadroughts, extreme shifts in critical ecosystems, emerging reservoirs of new pathogens, or the sudden breakup of immense ice sheets. The national security implications of such changes could be severe.

Effects of Climate Change on U.S. National Security: Possible Timeframes

The major forces driving climate are understood well enough for models to forecast climate trends for general regions, but complex interactions in the climate system, modeling uncertainties, and human choices make it difficult to project when and where specific weather and climate effects will most significantly affect national security. Most scientists expect that climate change generally will exacerbate current conditions—for example, making hot, dry places hotter and drier.

Future climate conditions could be altered significantly by government policies, industrial practices, or consumer behavior regarding greenhouse gas emissions. That said, IPCC scenario modeling suggests that aggressive environmental policies would not begin to slow the growth of global average surface temperatures for another 15-20 years because of the lag time for complex global climate systems to respond to changes in human behavior (see chart on page 19).

The long time horizon for climate change makes for different assessments

of the national security implications for different periods. We make these assessments based on the IPCC's findings of projected climate change and our understanding of the possible pathways by which climate change affects national security.

At present, the growing implications for humans of extreme weather events suggest that climate-change related disruptions are well underway. Individual weather occurrences remain difficult to attribute entirely to climate change, however.

Looking forward, we assess that during the next five years national security risks linked to climate change will arise mostly from distinct extreme weather events, especially in regions with weak governance, poor living conditions, or persistent conflict that limit the capacity of governments and societies to cope with additional stress. When extreme events occur where they have not before, that too will be disruptive, even for advanced industrial countries.

We assess that during the next 20 years—in addition to increasingly disruptive extreme weather events—climate change effects will play out in broader, systemic ways, such as more acidic oceans, degraded soil and air quality, and rising sea levels, resulting in sustained direct and indirect effects on U.S. national security. Weather events of modest severity will be disruptive when their impacts are compounded as part of a rapid sequence or in clusters.

News and Announcements

Renewable Natural Resources Foundation

RNRF Welcomes New Program Director

Nicolas H. Kozak of Bethesda, Md. is RNRF's new program director. He started working with RNRF in September of 2016.

Kozak recently earned a B.S. in environmental science and policy at the University of Maryland - College Park. While at Maryland, he was selected for and participated in the College Park Scholars - Environment, Technology, and Economy Program.

Kozak was a sustainability intern with the Apartment and Office Building Association of Metro Washington (AOBA) where he performed extensive work on LEED and Energy Star certification. He also interned with The Tower Companies and advanced their LEED agenda through his work on 1707 L



Nicolas H. Kozak

Street's LEED Dynamic Plaque.

In his position as program director, Kozak works with RNRF committees and staff in developing and implementing programs such as public policy conferences, congressional forums, RNRF's Washington Round Table on Public Policy, and the annual awards program. He also serves as assistant editor of the *Renewable Resources Journal* and as RNRF's webmaster.

Summer Meeting on "Big Data" for Assessing Global Water Risk, and Improving Urban Planning

The RNRF Board of Directors and guests met on June 28, 2016, in Washington, D.C. to discuss how "big data" is being used to assess global water risk, and improve urban planning.

Aqueduct Water Risk Atlas

Charles Iceland, Aqueduct Director; Foods, Forests, and Water Programs, World Resources Institute (WRI), described its online mapping tool to help companies, investors, governments, and communities to better understand where and how water risks are emerging around the world. He also described the data and technologies that have made Aqueduct possible, how it is used, its limitations, and plans for its expansion. Iceland's PowerPoint presentation can be accessed at http://www.rnrf.org/RNRF_06282016.pdf.

Big Data Applications to Urban Planning

Architect Klaus Philipsen, president of ArchPlan Inc. of Baltimore, Md., described the ways in which big data

concepts have been applied to improve urban planning and design. He also spoke about the early challenges and limitations associated with big data applications for integrated, sustainable design. Philipsen's PowerPoint presentation can be accessed at <http://www.rnrf.org/2016%20RNRF%20Smart%20Cities%200628.pdf>.

Round Table on Methane Emissions

The RNRF Washington Round Table on Public Policy met with David McCabe, atmospheric scientist with the Clean Air Task Force (CATF), in Washington, DC on June 22, 2016. The Round Table took place at the Washington, DC-office of the American Society of Civil Engineers on Capitol Hill. McCabe discussed recent efforts to regulate methane emissions.

He observed that CATF welcomes EPA's first-ever standards to directly address methane pollution, a highly potent greenhouse gas, over 80 times more powerful than CO₂ over the short run. By placing robust safeguards on new



David McCabe



Charles Iceland (L) and Klaus Philipsen (R) at RNRf's summer meeting.

and modified sources of methane from the oil and gas industry, now the leading emitter of methane in this country, the Obama Administration has taken an important step to protect our climate, as well as our public health.

EPA's action is important to stem the emissions from new and modified oil and gas infrastructure, as the Energy Information Administration estimates that natural gas production will grow by 13 percent by 2025. This action is also critically important as a stepping-stone to required emissions reductions from the existing equipment that constitutes the lion's share of methane pollution from the oil and gas industry. The proposed Information Collection Request represents a second step, aimed at providing EPA with the data it feels it needs to issue comprehensive safeguards on existing sources of methane across the oil and gas industry.

Reducing methane pollution from the oil and gas sector represents one of the most cost-effective climate mitigation opportunities, as a number of control measures can pay for themselves within just a few years. The standards are projected to reduce methane pollution by 510,000 tons a year—the equivalent of about a dozen coal-fired power plants—and save Americans about a hundred million dollars worth of natural gas. Methane is not only responsible for a quarter of man-made climate change but

it also contributes to unhealthy levels of ozone pollution—which is linked to asthma attacks, hospital admissions, as well as premature death.

The Path Ahead Will Benefit from the Following Measures:

- Cleaning up older equipment—compressors and gas-driven pneumatic equipment—with proven technologies and practices can reduce methane pollution by an estimated 1,200,000 to 1,350,000 metric tons per year. Current EPA standards require these technologies and practices for some new compressors and gas-driven pneumatic equipment in select segments of the industry, while states like Colorado extend some requirements to existing sources.
- Capturing natural gas that would otherwise be released from oil and gas wells can reduce methane pollution by an estimated 260,000 to 500,000 metric tons per year.

These methane abatement potentials are conservative estimates based on government inventories. They don't account for the research indicating that actual emissions could be twice the inventory estimates, or higher. The problem and the upsides of controlling it—are likely much greater. The cost of the new

standards will be low—less than one percent of the industry's sales revenue.

McCabe has been with CATF as atmospheric scientist since Jan. 2010, working primarily on short-lived pollutants. He holds a Ph.D. in chemistry from the University of Colorado and a B.A. in geography and chemistry from the University of Chicago. Visit http://www.rnrf.org/Mind_the_Gap.pdf to access CATF's report on methane emissions - "Mind the Gap"

Round Table on the Smart Grid

The Brattle Group hosted RNRf's Washington Round Table on Public Policy at its Washington, D.C. office on April 20, 2016. Heidi Bishop, a senior policy and marketing analyst with the group, discussed the status of smart grid development, renewable energy trends, and the integration of renewables into smart grids.

According to the Department of Energy (DOE), "smart grid" generally refers to a class of technology using computer-based remote control and automation, including two-way communication technology and computer processing that has been used in other industries for decades. In essence, a smart grid "computerizes" the electric utility grid.

Status of Smart Grid Development

Bishop highlighted DOE's description of the functional characteristics of a smart grid. These include:

- Self-healing from power disturbance events, i.e., a smart grid can identify when and where power is down, and respond either by self-healing or sending an alert.
- Enabling active participation by consumers in demand response.
- Operating resiliently against physical and cyber attack.
- Providing power quality for 21st

century needs.

- Accommodating all generation and storage options.
- Enabling new products, services, and markets.
- Optimizing assets and operating efficiently.

A smart grid involves deployment of these technologies across the entire system, from transmission, to distribution, to consumption. On the consumer end, almost 60 million households have smart meters today. For example, Pacific Gas and Electric Company (PG&E), a California electric utility, implements a “SmartMeter” program that is part of a statewide effort driven by the California

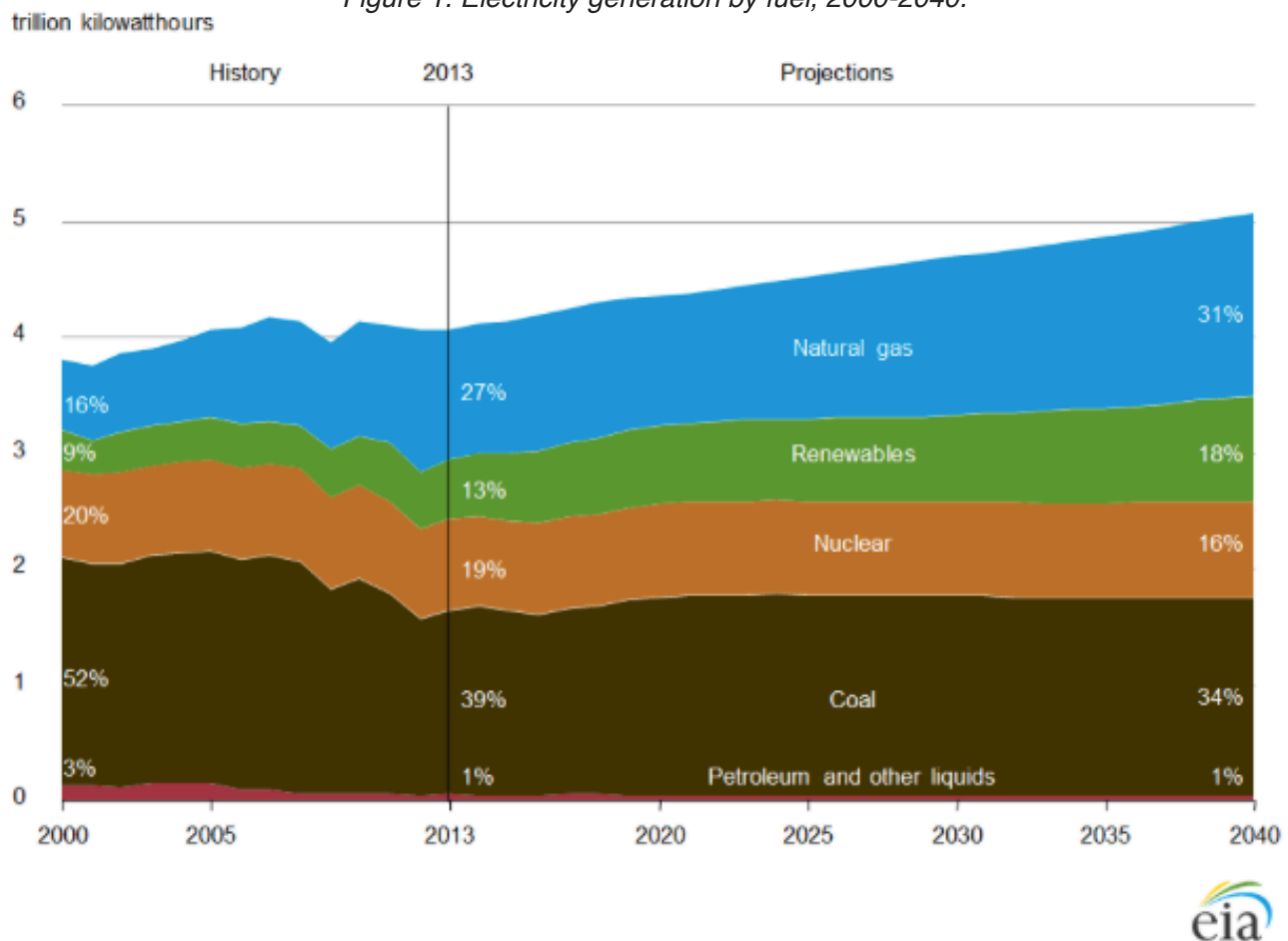
Public Utilities Commission to upgrade the state’s energy infrastructure. The new meters provide two-way communication between PG&E and the consumer. These meters help PG&E provide more reliable service by using the information from two-way communication to quickly identify outages and resolve other service problems. Consumers can make more informed energy decisions with detailed information about their usage, including alerts that notify consumers when their energy use is on pace to exceed a personalized bill alert amount. Additionally, consumers can opt into a rate structure based on the time of day electricity is used. PG&E also offers the options to opt into a net-

work that connects smart devices in the home that automatically respond to energy usage from the grid.

Status of Renewable Development

According to the U.S. Energy Information Administration (EIA), the mix of fuels used to generate electricity in the United States has changed significantly since 1990. For example, coal-fired power plants accounted for 42% of U.S. electricity generation capacity in 1990 (and produced more than half of the total electricity supply), but decreased to 28% of generation capacity in 2014 (and produced 39% of electricity supply). Electricity generation from

Figure 1. Electricity generation by fuel, 2000-2040.



Source: U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2015*, Reference case (April 2015)

wind has experienced significant gains in its share of electric generation capacity, growing from 0.2% in 1990 to about 6% in 2014. Electricity generated from solar energy rose from almost 0% in 1990 to 1% in 2014. EIA projects that by 2040, renewables will be responsible for 18% of all electricity generation (see figure 1) According to Bishop, electricity generation from renewable sources is expected to grow by 9% this year alone, consisting primarily of wind, with some solar. Bishop noted that renewable energy development has been driven by Renewable Portfolio Standards (RPS), the Clean Power Plan, declining solar prices, concerns about energy resilience, and consumer preference. Photovoltaic (PV) energy in particular has received increased attention. Technological advances have driven module costs down, and third-party financing has expanded the residential market for rooftop solar. The penetration of distributed energy resources (DER), which includes solar, has been increasing in key states, including California, New Jersey, and Arizona.

Integration of the Smart Grid and Renewables

Bishop stressed that renewable integration is a key component of smart grid development and distribution plans. The “grid of the future” requires the meshing of several different systems. Smart grid functions support renewable integration through better forecasting, smart inverters, demand response, integrated storage batteries tied to solar, and real-time system awareness and management. According to the DOE, the goal of renewable energy integration is to:

- Reduce carbon emissions and emissions of other air pollutants through increased use of renewable energy and other clean distributed generation.

- Increase asset use through integration of distributed systems and customer loads to reduce peak load and thus lower the costs of electricity.
- Support achievement of renewable portfolio standards for renewable energy and energy efficiency.
- Enhance reliability, security, and resiliency from microgrid applications in critical infrastructure protection and highly constrained areas of the electric grid.
- Support reductions in oil use by enabling plug-in electric vehicle (PHEV) operations with the grid.

Grid modernization poses technological and regulatory challenges for both utilities and their regulators. Utilities must weight the value of DER to the rest of the system, cost and benefits of different strategies for deploying DER, and many other considerations. State Public Utilities Commissions are becoming active in guiding smart grid development through dockets on grid modernization and “utility of the future” dockets. The current U.S. electric grid is being stretched to its capacity as energy use increases and shifts. To move forward, the grid must be modernized and built to manage the increasing complexity and needs of energy consumers in the 21st century.

American Geophysical Union

AGU Aspires to Achieve Net Zero Goal

The American Geophysical Union recently announced formal approval from its board of directors to undertake a \$41.7 million complete renovation of its 62,000-square-foot headquarters building, located in the Dupont Circle neighborhood. AGU is aspiring to be the first organization in the District of Columbia to renovate an existing commercial building to achieve net zero goals.

AGU is an organization dedicated to

advancing science and ensuring a sustainable future. Recognizing that the aging building and infrastructure would require a major renovation after 20 years of service, AGU seized upon an opportunity to lead by example. In addition to creating a welcoming and collaborative space for its members and the D.C. community that would facilitate the understanding of Earth and space science, the organization chose to design and engineer the modernization of the building to meet net zero goals. In so doing, AGU will be able to showcase real-world scientific advancement through innovative sustainable technology. The project is expected to be a model for reducing the carbon and environmental impacts of business operations in a cost-effective and replicable way.

“AGU strives to be an innovative leader and partner that advances and communicates science’s power to ensure a sustainable future—which must include re-envisioning our workplaces as livable, interconnected environments that are energy efficient, minimize our carbon footprint in the public space, and provide a healthy and dynamic ecosystem for our members and staff,” said AGU’s Executive Director and CEO Chris McEntee. “It must also provide an opportunity to pave the way for others looking to incorporate similar approaches and designs into new and existing facilities throughout our city.”

The renovated headquarters building will also provide a collaborative, state-of-the-art conference center and work space for AGU members, the public, and staff. As a scientific destination in the nation’s capital, the new building will include an interactive public exhibit that highlights the impacts and innovations of Earth and space science.

The board approval represents a significant milestone capping off an 18-month-long approval process. Throughout, AGU’s goal has been to respect the historic values of the surrounding area, and ensure public understanding of the

project and its potential impacts. The project has received unanimous endorsements from Advisory Neighborhood Commission 2B (ANC 2B), and unanimous approvals from the Historic Preservation Review Board and the Board of Zoning Adjustment.

With approval secured from the proper agencies and regulatory bodies, contractors are now preparing for the first phase of construction to begin in March 2017. The building is expected to re-open in 2018 in time for the organization's 51st annual Fall Meeting, which will bring more than 20,000 scientists to the District in December 2018. This re-opening will also serve as the unofficial kick-off for AGU's centennial celebration, which will take place in 2019.

"We are excited to host AGU's annual meeting for the first time in Washington," said Destination DC President and CEO Elliott Ferguson. "It is perfect timing as they have completed a world-class renovation of their headquarters in Dupont Circle that their members can visit while meeting in the nation's capital."

Whereas other development projects are striving for net zero in their initial planning stages, this project is different in that it requires the overhaul of an existing commercial building. A building reaches net zero when it realizes an annual balance between energy demand and the creation of energy on-site. This balance will be achieved through a variety of architectural, engineering, and advanced technology methods which reduce, reclaim, absorb, or generate energy or water, including:

- 11-foot-6-inch high solar rooftop photovoltaic (PV) array to help generate on-site renewable energy
- Municipal sewer heat exchange system to recover thermal energy from wastewater beneath Florida Avenue
- Green wall to help reduce energy load and improve indoor air quality

- Water cistern to collect rainwater from the roof, as well as condensate water from the dedicated outdoor air system, to produce all the water needed for flushing low-flow toilets and irrigating on-site
- Direct current (DC) electrified grid with DC LED lighting, which will allow the building to be more energy efficient and use power generated by the solar PV array
- Radiant cooling system that circulates chilled water through a network of pipes and uses less energy than a traditional forced-air system
- Enhanced building envelope insulation, dynamic glass shading, and triple-pane glazing, among other interior and exterior high performance strategies

Furthermore, the project goes well beyond net zero energy usage to include other sustainability elements by reusing unique architectural elements, repurposing existing building materials, and offsite recycling of demolition and construction debris.

AGU looks forward to continued collaboration and support with the surrounding neighborhood, city officials, and stakeholders as the construction phase begins. For more information on the project, please visit <http://building.agu.org>.

American Meteorological Society

AMS Releases Report on "Explaining Extreme Events from a Climate Perspective" for the Year 2015

In December 2016, the American Meteorological Society released a report on "Explaining Extreme Events from a Climate Perspective" for the year 2015 as a special supplement to volume 97-issue number 12, of its Bulletin of the American Meteorological Society Magazine. This report is the fifth of its kind

in a series of reports focused on explaining extreme events of the previous year.

This fifth edition continues to provide evidence that climate change is altering some extreme event risk. Without exception, all the heat-related events studied in this year's report were found to have been made more intense or likely due to human-induced climate change. This was discernible even for those events strongly influenced by the 2015 El Niño. Furthermore, many papers in this year's report demonstrate that attribution science is capable of separating the effects of natural drivers including the strong 2015 El Niño from the influences of long-term human-induced climate change.

Other event types investigated include cold winters, tropical cyclone activity, extreme sunshine in the United Kingdom, tidal flooding, precipitation, drought, reduced snowpack in the U.S. mountain west, arctic sea ice extent, and wildfires in Alaska. Two studies investigated extreme cold waves and monthly-mean cold conditions over eastern North America during 2015, and find these not to have been symptomatic of human-induced climate change. Instead, they find the cold conditions were caused primarily by internally generated natural variability. One of these studies shows winters are becoming warmer, less variable, with no increase in daily temperature extremes over the eastern United States. Tropical cyclone activity was extreme in 2015 in the western North Pacific (WNP) as measured by accumulated cyclone energy (ACE). In this report, a study finds that human-caused climate change largely increased the odds of this extreme cyclone activity season. The 2015 Alaska fire season burned the second largest number of acres since records began in 1940. Investigators find that human-induced climate change has increased the likelihood of a fire season of this severity.

Confidence in results and ability to quickly do an attribution analysis de-

pend on the “three pillars” of event attribution: the quality of the observational record, the ability of models to simulate the event, and our understanding of the physical processes that drive the event and how they are being impacted by climate change. A result that does not find a role for climate change may be because one or more of these three elements is insufficient to draw a clear conclusion. As these pillars are strengthened for different event types, confidence in the presence and absence of a climate change influence will increase.

This year researchers also link how changes in extreme event risk impact human health and discomfort during heat waves, specifically by looking at the role of climate change on the wet bulb globe temperature during a deadly heat wave in Egypt. This report reflects a growing interest within the attribution community to connect attribution science to societal impacts to inform risk management through “impact attribution.” Many will watch with great interest as this area of research evolves in the coming years.

To view this and past reports, please visit the following webpage: <https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-from-a-climate-perspective/>.

For more information on the American Meteorological Society’s “Bulletin of the American Meteorological Society Magazine,” please visit: <https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/>.

American Society of Civil Engineers

ASCE Announces World’s First Comprehensive Tsunami Resilient Design Standards

Despite disastrous tsunamis striking Japan, Chile, Samoa, and the Indian Ocean in recent years, and the very real threat of a similar tsunami hitting the United States, no consensus standard exists to design against the impact of a tsunami. Today, the American Society of Civil Engineers announced the world’s first comprehensive tsunami-resilient design standards, incorporating the lessons learned from these past disasters to define an enforceable, state-of-the-art design code for the construction of safer buildings on the West Coast of the United States, Alaska, and Hawaii - all high-risk areas for tsunamis.

As a part of the tsunami design criteria and methodology, ASCE collaborated with the University of Washington Joint Institute for the Study of the Atmosphere and Ocean (JISAO) and AECOM to develop region-specific maps graphically depicting the extent of tsunami inundation. The maps reveal that nearly 3.5 million residents on the West Coast of the U.S., Alaska and Hawaii are at risk to the impacts of a tsunami.

For more information, contact ASCE, 1801 Alexander Bell Drive, Reston, VA 20191; (800) 548-2723. <http://www.asce.org>.

American Society of Landscape Architects

ASLA Releases New Guide to Resilient Design

A new online guide launched by the American Society of Landscape Architects (ASLA) explains how communities can better protect themselves from natural disasters through resilient landscape planning and design. The Resilient Design Guide is found here: <https://www.asla.org/resilient>.

According to the guide, the goal of resilient landscape planning and design is to retrofit communities to recover

more quickly from extreme events, now and in the future. The guide is organized around disruptive events that communities now experience: drought, extreme heat, fire, flooding and landslides. Biodiversity loss is an underlying threat also explored.

The guide includes hundreds of case studies and resources demonstrating multi-benefit systems as well as small-scale solutions. It also explains landscape architects’ role in the planning and design teams helping to make communities more resilient.

Resilient design involves working with nature—instead of in opposition to it. It provides value to communities, including:

Risk Reduction

As events become more frequent and intense due to climate change, communities must adapt and redevelop to reduce potential risks and improve ecological and human health. It’s also time to stop putting communities and infrastructure in high-risk places. And communities must reduce sprawl, which further exacerbates the risks.

Scalability and Diversity

Resilient landscape planning and design offers a multi-layered system of protection, with diverse, scalable elements, any one of which can fail safely in the event of a catastrophe.

Multiple Co-Benefits

Resilient landscape designs offer multiple benefits. Designed coastal buffers can also provide wildlife habitat and recreation opportunities; urban forests made up of diverse species clean the air while reducing the urban heat island effect; and green infrastructure for controlling flooding also provides needed community space and creates jobs.

Regeneration

Disruptive natural events that are now occurring more frequently worldwide harm people and property. Resilient design helps communities come back stronger after these events. Long-term resilience is about continuously bouncing back and regenerating. It's about learning how to cope with the ever-changing "new normal."

In an era when disasters can cause traditional, built systems to fail, adaptive, multi-layered systems can maintain their vital functions and are often more cost-effective and practical solutions. In an age of rising waters and temperatures and diminishing budgets, the best defenses are adaptive, like nature.

For more information, contact ASLA, 636 Eye Street, NW, Washington, DC, 20001; (202) 898-2444.

American Water Resources Association

AWRA to Host Free Webinar on Western Water

John R. Fleck, director of the University of New Mexico's Water Resources Program, argues in his new book, "Water is for Fighting Over and Other Myths About Water in the West" that the "water is for fighting over" mantra is actually a myth in the western US. When people have less water, they actually use less water. Using the over-allocated Colorado River as an example, Fleck shows that collaboration and cooperation among the seven basin states is far more prevalent than the media accounts would have us believe. He weaves a compelling tale, one that will have us more carefully scrutinize the "Western water wars" headlines that are all too common today. AWRA will be hosting a free webinar with Fleck on January 18, 2017 at 1:00 pm EST. Q&A will follow and PDH credit will be available to attendees.

For more information, contact AWRA, P.O. Box 1626, Middleburg, VA 20118; (540) 687-8390. <http://www.awra.org>.

Geological Society of America

GSA Releases Annual Meeting Abstract

The Geological Society of America has released an abstract of its 2016 Annual Meeting, which took place in Denver, Co. on September 25-28.

In navigating the abstract, one can view all sessions for a selected day, and view all presentations within that session. For more information and detailed instructions, visit the page for GSA's annual meeting at <https://gsa.confex.com/gsa/2016AM/webprogram/start.html>.

Society of Environmental Toxicology and Chemistry

SETAC North America's 38th Annual Meeting

SETAC is seeking experts in a range of environmental toxicology and chemistry fields willing to aid in the advancement of research and to share their knowledge at the SETAC North America 38th Annual Meeting, which will be held from November 12-16, 2017 in Minneapolis, Minnesota. Researchers and scientists are encouraged to submit a session proposal and professional training course proposal on the meeting website.

Proposals should address timely and relevant topics in environmental toxicology and chemistry, be related to the meeting theme, "Toward a Superior Future: Balancing Chemical Use and Ecosystem Health," or reflect local (Minneapolis or Minnesota), national or international research interests.

Accepted session formats include platforms and posters, Oxford-style de-

bates, educational games or activities, and interactive platforms and posters.

The deadline to submit a session proposal is February 22. The deadline for professional training course proposals is May 1.

For more information, contact SETAC, 229 S. Baylen Street, Pensacola FL 32502; (850) 469-1500.

International News

Conservation International

OHI announces 5th Annual Global Ocean Health Assessment Score

On December 8, 2016, the Ocean Health Index (OHI) announced its 5th annual global ocean health assessment score, 71 out of a possible 100, at the 18th annual Global Environment Facility Large Marine Ecosystem meeting in Paris. The 2016 score remains overall the same as global scores for 2012-2015 (despite a minor, yet statistically insignificant, increase in 2013), all of which are based on updated data and goal score calculations. The OHI, established in 2012, is a partnership led by scientists from the National Center for Ecological Analysis and Synthesis at the University of California, Santa Barbara and Conservation International.

A consecutive global score of 71 indicates that, while the ocean has remained at a stable state, it is far from the desired 100 indicative of a fully sustainable ocean. At the individual Exclusive Economic Zone (EEZ) scale, however, high scores for populated areas such as Germany (ranked 4th among the 220 EEZs assessed, with a score of 85 and a population of 81 million) and Seychelles (ranked 8th, with a score of 84 and a population about 97,000) exemplify the necessity of effective social and environmental governance systems for improving ocean health.

The OHI combines and compares the biological, physical, economic and

social elements of ocean health to assess how sustainably ocean resources are utilized within a given region. The scores, which range on a scale from 0 to 100, provide decision makers with a tool to holistically understand, track and communicate the status of ocean health and, thus, promote the most effective actions for improved ocean management at sub-national, national, regional and global scales.

“Understanding all of the factors contributing, both positively and negatively, to the current state of our oceans is the first step toward ensuring the ocean can continue to provide benefits to humans,” said Dr. Johanna Polsenberg, Senior Director of Governance and Policy for Conservation International’s Center for Oceans. “By also offering a means to advance ocean policies at different scales and measure future progress, the Ocean Health Index provides a cross-sectoral coordinating platform for informing decisions about how to manage and protect marine ecosystems in an integrated way.”

The Ocean Health Index team is working directly with more than 25 countries leading their own independent OHI assessments, also known as the OHI+, across priority marine regions such as the Pacific Oceanscape, East Africa, and Southeast Asia. OHI+ assessments have already driven marine conservation actions at the national level, such as helping shape China’s 13th 5-year plan, Ecuador’s National Plan for Good Living and Mexico’s National Policy on Seas and Coasts. By providing an annual comprehensive database baseline for global ocean health, the OHI offers all coastal countries, at any level of capacity, a starting place for assessing the status of their marine resources and environments and utilizing an ecosystem-based approach toward management.

“What is really exciting about having several years of assessment done is we can start to see where and by how much scores are changing year to year, and begin to understand the causes and consequences of those changes,” said Ben Halpern, Chief Scientist for the Ocean Health Index project. “We’ve given the oceans their annual check-up and the results are mixed. It’s as if you went to the doctor and heard that, although you don’t have a terminal disease, you really need to change your diet, exercise a lot more and get those precancerous skin lesions removed. You’re glad you’re not going to die but you need to change your lifestyle.”

Five years of global Ocean Health Index assessments have identified potential trends in ocean health. The Livelihoods & Economies goal showed the most rapid score increase between 2012 and 2013, possibly reflecting recovery from the recession that began in 2008; and Lasting Special Places, a sub-goal of Sense of Place, scores improved by an average of 0.5 points per year, likely due to the designation of marine protected areas.

Consistently low scores for Tourism & Recreation (47) highlight that countries are not sustainably maximizing benefits that can be derived from a healthy tourism sector and scores for Food Provision (54) and Natural Products (48) indicate that many regions are either harvesting unsustainably or are not maximizing their sustainable potential to produce more food from the sea. Furthermore, the overarching issue of poor quality data (or no data at all) limits the ability to estimate the status of fish stocks in many regions as well as the overall status of fisheries.

While Biodiversity (91) and Coastal Protection (87) remain the highest scoring goals, reference points for both goals include maintaining coastal habitats at or about their extent in 1980, so

decline of their scores from 100 have occurred in less than four decades. Continuing threats to habitat condition would lower scores further.

“We believe the Ocean Health Index gives reason for hope by providing a detailed diagnosis of the state of ocean health and also a framework that allows countries to identify and prioritize the most necessary resilience actions to improve ocean health,” said Polsenberg. “This is where our work is most valuable. It may take some time for such actions to be reflected in the scores—but the steps being taken are essential to ensure a healthy ocean into the future.”

For more information, visit <http://www.conservation.org/NewsRoom/pressreleases/Pages/Ocean-Health-Index-Releases-5th-Annual-Global-Ocean-Health-Assessment-Score-71100.aspx>.

Arctic Council

Arctic Resilience Report Released

The signs of change are everywhere in the Arctic: Temperatures nearly 20°C above the seasonal average are being registered over the Arctic Ocean. Summer sea-ice cover has hit new record lows several times in the past decade. Infrastructure built on permafrost is sinking as the ground thaws underneath.

Yet those are only snapshots of a much larger trend. The Arctic Resilience Report shows that Arctic ecosystems are fundamentally threatened by climate change and other impacts of human activities. It identifies 19 tipping points (or “regime shifts”) that can and have occurred in Arctic marine, freshwater and terrestrial ecosystems.

These regime shifts affect the stability of the climate and landscape, plant and animal species’ ability to survive, and Indigenous Peoples’ subsistence and ways of life.

The Arctic Resilience Report, produced by an international team of researchers under the auspices of the Arctic Council, highlights the need to enhance cooperation, both to tackle the drivers of Arctic change, and to build resilience among Arctic people. The report finds that policies and actions of Arctic countries' governments have sometimes hurt resilience, which calls for increased work to support and empower local communities.

"The resilience of Arctic social-ecological systems depends not only on the commitment and imagination of Arctic people, but on the support provided by Arctic countries' governments, non-governmental organizations, industry and others," it concludes.

"Ultimately, realizing resilience in the Arctic will depend on empowering the people of the North to self-organize, define challenges in their own terms, and find their own solutions, knowing that they have the flexibility and external support to implement their plans."

Responding to Arctic change: a selection of 25 case studies from across the Arctic were analysed for this report. The cases illustrate both loss of resilience and resilience, including instances of transformational change.

The Arctic Resilience Report is the culmination of a five-year scientific effort to better understand the nature of Arctic change, including critical tipping points. It also examines the factors that support resilience, and the kinds of choices that strengthen adaptive capacity.

The report builds on a large and growing body of research on environmental change in the Arctic, but adds substantial new insights by drawing on resilience science to integrate social and ecological perspectives.

"One of the study's most important findings is that not only are regime shifts occurring, but there is a real risk that one regime shift could trigger others, or simultaneous regime shifts could have unexpected effects," said Johan L. Kuylensstierna, executive director of the Stockholm Environment Institute.

Johan Rockström, executive director of the Stockholm Resilience Centre and co-chair of the project, added: "How regime shifts interact with one another is poorly understood. If multiple regime shifts reinforce each other, the results could be potentially catastrophic. The variety of effects that we could see means that Arctic people and policies must prepare for surprise. We also expect that some of those changes will destabilize the regional and global climate, with potentially major impacts."

The study also examines how Arctic people are adapting to change. It finds multiple examples of communities that have lost their livelihoods and are struggling to survive or maintain their cultural identity.

Still, the report highlights several examples of resilient Arctic communities that have maintained traditional whaling, reindeer herding and other practices despite external shocks. Others have transformed themselves: from nomadic hunters to internationally recognized artists in Cape Dorset, Nunavut,

Canada, for instance, and from fishing to whale-watching tours in Húsavík, Iceland.

The single most important factor in resilience, the analysis shows, is the ability to self-organize and respond to challenges as a community.

"For those of us in the policy arena, this provides an important reminder that empowerment and training for northern communities is paramount for addressing resilience in the region," said Joel Clement, co-chair of the Arctic Resilience Report project.

Other key factors for resilience are the ability to draw on diverse knowledge sources, including local traditions as well as science; having diversity (e.g. in livelihoods); and being able to navigate change and uncertainty.

The study also examines the role of the Arctic Council in building resilience, which is complex not least because diverse Arctic actors define their interests and goals in the region in very different ways: Some see it as a home, others as a source of minerals and other resources, others mostly for its role as a key part of a global system of climate regulation.

The Arctic Council has been effective at fostering cooperation in a variety of important ways; now it just needs to enhance its efforts, the report finds.

Source - Stockholm Resilience Centre
To download the original report, please go to https://oaarchive.arctic-council.org/bitstream/handle/11374/1838/A_R_R_full_report_low-res_161114b.pdf?sequence=1&isAllowed=y.

Meetings

See <http://www.rnrf.org> for additional meetings

Submit Meeting Notices to: info@rnrf.org

January 2017

World Economic Forum Annual Meeting. January 17-20, 2017. Davos-Kloster, Switzerland. <https://www.weforum.org/events/world-economic-forum-annual-meeting-2017/>

American Meteorological Society's 97th Annual Meeting: Observations Lead the Way. January 22-26, 2017. Seattle, WA. <https://annual.ametsoc.org/2017/>

American Geophysical Union Chapman Conference on Extreme Climate Event Impacts on Aquatic Biogeochemical Cycles and Fluxes. January 22-27, 2017. San Juan, Puerto Rico, USA. <http://chapman.agu.org/extremeclimate/>

NCSE 2017 National Conference and Global Forum. January 24-26, 2017. Washington, DC. <http://www.ncseconference.org/>

American Geophysical Union Chapman Conference on Submarine Volcanism: New Approaches and Research Frontiers. January 29-February 3, 2017. Hobart, Tasmania, Australia. <http://chapman.agu.org/submarinevolcanism/>

February 2017

New Partners for Smart Growth 2017 Conference. February 2-4, 2017. St. Louis, MO. <https://www.newpartners.org/about-the-event/>

Fourth Santa Fe Conference on Global and Regional Climate Change. February 5-10, 2017. Santa Fe, NM. <http://www.cvent.com/d/wfq4zq>

AAAS Annual Meeting: Serving Society Through Science Policy. February 16-20, 2017. Boston, MA. <http://meetings.aaas.org/>

March 2017

50th International Conference on Water Management Modeling. March 1-2, 2017. Toronto, Canada. <http://www.icwmm.org/>

Multi-State Salinity Coalition Annual Salinity Summit. March 2-3, 2017. Las Vegas, NV. <http://multi-statesalinitycoalition.com/events/>

82nd North American Wildlife and Natural Resources Conference. March 4-11, 2017. Spokane, WA. <https://wildlifemanagement.institute/conference>

2017 GIS/CAMA Technologies Conference. March 6-9, 2017. Chattanooga TN. <http://www.urisa.org/events/2017/03/06/conference/2017-gis-cama-technologies-conference/>

Sustainable Water Management Conference. March 19-22, 2017. New Orleans, LA. <http://www.awwa.org/conferences-education/conferences/sustainable-water-management.aspx>

Global Forum for Innovations in Agriculture 2017. March 20-21, 2017. Abu Dhabi, UAE. <http://www.innovationsinagriculture.com/>

DC Environmental Film Festival 25th Anniversary. March 14-26, 2017. Washington, DC. <http://dceff.org/>

April 2017

253rd American Chemical Society National Meeting and Exposition. April 2-6, 2017. San Francisco, CA. <https://www.acs.org/content/acs/en/meetings.html>

Northeast Association of Fish and Wildlife Agencies 73rd Annual Conference. April 9-11, 2017. Norfolk, VA. <http://www.neafwa.org/conference.html>

2017 Spring AWRA Conference. April 30- May 3, 2017. Snowbird, UT. <http://www.awra.org/meetings/Snowbird2017/>

May 2017

National Hydropower Association Annual Conference. May 1-3, 2017. Washington, DC. <http://www.hydro.org/news-and-media/events/details/2017-waterpower-week-in-washington-annual-conference-imrec-and-mets/>

Offshore Technology Conference. May 1-4, 2017. Houston, TX. <http://2017.otcnet.org/>

RENEWABLE RESOURCES JOURNAL

Renewable Natural Resources Foundation

6010 Executive Boulevard, 5th Floor

N Bethesda, MD 20852-3827 USA