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Fourth National Climate Assessment: Impacts, Risks, and Adaptation in the United States¹

U.S. Global Change Research Program²

Editor's note

The National Climate Assessment is an extensive and authoritative interagency report on climate change and its impacts in the United States. This report, which was developed through the collaborative efforts of the U.S. Global Change Research Program, is required by statute to be issued every four years. The latest report was released in November 2018. Notably, the report's conclusions directly conflict with the Trump Administration's agenda to weaken policies and regulations designed to combat climate change.

Summary Findings

These Summary Findings represent a high-level synthesis of the material in the underlying report. The findings consolidate Key Messages and supporting evidence from 16 national-level topic chapters, 10 regional chapters, and 2 chapters that focus on societal response strategies (mitigation and adaptation). Unless otherwise noted, qualitative statements regarding future conditions in these Summary Findings are broadly applicable across the range of different levels of future climate change and associated impacts considered in this report.

Communities

Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.

The impacts of climate change are already being felt in communities across the country. More frequent and intense extreme weather and climate-related events, as well as changes in average climate conditions, are expected to continue to damage infrastructure, ecosystems, and social systems that provide essential benefits to communities. Future climate change is expected to further disrupt many areas of life, exacerbating existing challenges to prosperity posed by aging and deteriorating infrastructure, stressed ecosystems, and economic inequality. Impacts within and across regions will not be distributed equally. People who are already vulnerable, including lower-income and other marginalized communities, have lower capacity to prepare for and cope with extreme weather and climate-related events and are expected to experience greater impacts. Prioritizing adaptation actions for the most vulnerable populations would

¹ The Fourth National Climate Assessment was developed in two volumes - Volume I: Climate Science Special Report and Volume II: Impacts, Risks, and Adaptation in the United States. Volume I, released in November 2017, provides a U.S.-focused assessment of climate change science. Volume II, released in November 2018, uses the scientific assessment in Volume I to inform its analysis of climate change impacts facing the United States. Volume II is highlighted in this overview article.

² The U.S. Global Change Research Program is comprised of the following thirteen federal agencies: Department of Agriculture; Department of Commerce; Department of Defense; Department of Energy; Department of Health & Human Services; Department of the Interior; Department of State; Department of Transportation; Environmental Protection Agency; National Aeronautics & Space Administration; National Science Foundation; Smithsonian Institution; U.S. Agency for International Development.

contribute to a more equitable future within and across communities. Global action to significantly cut greenhouse gas emissions can substantially reduce climate-related risks and increase opportunities for these populations in the longer term.

Economy

Without substantial and sustained global mitigation and regional adaptation efforts, climate change is expected to cause growing losses to American infrastructure and property and impede the rate of economic growth over this century.

In the absence of significant global mitigation action and regional adaptation efforts, rising temperatures, sea level rise, and changes in extreme events are expected to increasingly disrupt and damage critical infrastructure and property, labor productivity, and the vitality of our communities. Regional economies and industries that depend on natural resources and favorable climate conditions, such as agriculture, tourism, and fisheries, are vulnerable to the growing impacts of climate change. Rising temperatures are projected to reduce the efficiency of power generation while increasing energy demands, resulting in higher electricity costs. The impacts of climate change beyond our borders are expected to increasingly affect our trade and economy, including import and export prices and U.S. businesses with overseas operations and supply chains. Some aspects of our economy may see slight near-term improvements in a modestly warmer world. However, the continued warming that is projected to occur without substantial and sustained reductions in global greenhouse gas emissions is expected to cause substantial net damage to the U.S. economy throughout this century, especially in the absence of increased adaptation efforts. With continued growth in emissions at historic rates, annual losses in some economic sectors are projected to reach hundreds of billions of dollars by the end of the century—more than the current gross domestic product (GDP) of many U.S. states.

Interconnected Impacts

Climate change affects the natural, built, and social systems we rely on individually and through their connections to one another. These interconnected systems are increasingly vulnerable to cascading impacts that are often difficult to predict, threatening essential services within and beyond the Nation’s borders.

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:

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Editorial Staff: Robert D. Day, editor; Madeline Voitier, assistant editor; Stephen Yaeger, assistant editor.

Climate change presents added risks to interconnected systems that are already exposed to a range of stressors such as aging and deteriorating infrastructure, land-use changes, and population growth. Extreme weather and climate-related impacts on one system can result in increased risks or failures in other critical systems, including water resources, food production and distribution, energy and transportation, public health, international trade, and national security. The full extent of climate change risks to interconnected systems, many of which span regional and national boundaries, is often greater than the sum of risks to individual sectors. Failure to anticipate interconnected impacts can lead to missed opportunities for effectively managing the risks of climate change and can also lead to management responses that increase risks to other sectors and regions. Joint planning with stakeholders across sectors, regions, and jurisdictions can help identify critical risks arising from interaction among systems ahead of time.

Actions to Reduce Risks

Communities, governments, and businesses are working to reduce risks from and costs associated with climate change by taking action to lower greenhouse gas emissions and implement adaptation strategies. While mitigation and adaptation efforts have expanded substantially in the last four years, they do not yet approach the scale considered necessary to avoid substantial damages to the economy, environment, and human health over the coming decades.

Future risks from climate change depend primarily on decisions made today. The integration of climate risk into decision-making and the implementation of adaptation activities have significantly increased since the Third National Climate Assessment in 2014, including in areas of financial risk reporting, capital investment planning, development of engineering standards, military planning, and disaster risk management. Transformations in the energy sector—including the displacement of coal by natural gas and increased deployment of renewable energy—along with policy actions at the national, regional, state, and local levels are reducing greenhouse gas emissions in the United States. While these adaptation and mitigation measures can help reduce damages in a number of sectors, this assessment shows that more immediate and substantial global greenhouse gas emissions reductions, as well as regional adaptation efforts, would be needed to avoid the most severe consequences in the long term. Mitigation and adaptation actions also present opportunities for additional benefits that are often more immediate and localized, such as improving local air quality and economies through investments in infrastructure. Some benefits, such as restoring ecosystems and increasing community vitality, may be harder to quantify.

Water

The quality and quantity of water available for use by people and ecosystems across the country are being affected by climate change, increasing risks and costs to agriculture, energy production, industry, recreation, and the environment.

Rising air and water temperatures and changes in precipitation are intensifying droughts, increasing heavy downpours, reducing snowpack, and causing declines in surface water quality, with varying impacts across regions. Future warming will add to the stress on water supplies and adversely impact the availability of water in parts of the United States. Changes in the relative amounts and timing of snow and rainfall are leading to mismatches between water availability and needs in some regions, posing threats to, for example, the future reliability of hydropower production in the Southwest and the Northwest. Groundwater depletion is exacerbating drought risk in many parts of the United States, particularly in the Southwest and Southern Great Plains. Dependable and safe water supplies for U.S. Caribbean, Hawai'i, and U.S.-Affiliated Pacific Island communities are threatened by drought, flooding, and saltwater contamination due to sea level rise. Most U.S. power plants rely on a steady supply of water for cooling, and operations are expected to be affected by changes in water availability and temperature increases. Aging and deteriorating water infrastructure, typically designed for past environmental conditions, compounds the climate risk faced by society. Water management strategies that account for changing climate conditions can help reduce present and future risks to water security, but implementation of such practices remains limited.

Health

Impacts from climate change on extreme weather and climate-related events, air quality, and the transmission of disease through insects and pests, food, and water increasingly threaten the health and well-being of the American people, particularly populations that are already vulnerable.

Changes in temperature and precipitation are increasing air quality and health risks from wildfire and ground-level ozone pollution. Rising air and water temperatures and more intense extreme events are expected to increase exposure to waterborne and foodborne diseases, affecting food and water safety. With continued warming, cold-related deaths are projected to decrease and heat-related deaths are projected to increase; in most regions, increases in heat-related deaths are expected to outpace reductions in cold-related deaths. The frequency and severity of allergic illnesses, including asthma and hay fever, are expected to increase as a result of a changing climate. Climate change is also projected to alter the geographic range and distribution of disease-carrying insects and pests, exposing more people to ticks that carry Lyme disease and mosquitoes that transmit viruses such as Zika, West Nile, and dengue, with varying impacts across regions. Communities in the Southeast, for example, are particularly vulnerable to the combined health impacts from vector-borne disease, heat, and flooding. Extreme weather and climate-related events can have lasting mental health consequences in affected communities, particularly if they result in degradation of livelihoods or community relocation. Populations including older adults, children, low-income communities, and some communities of color are often disproportionately affected by, and less resilient to, the health impacts of climate change. Adaptation and mitigation policies and programs that help individuals, communities, and states prepare for the risks of a changing climate reduce the number of injuries, illnesses, and deaths from climate-related health outcomes.

Indigenous Peoples

Climate change increasingly threatens Indigenous communities' livelihoods, economies, health, and cultural identities by disrupting interconnected social, physical, and ecological systems.

Many Indigenous peoples are reliant on natural resources for their economic, cultural, and physical well-being and are often uniquely affected by climate change. The impacts of climate change on water, land, coastal areas, and other natural resources, as well as infrastructure and related services, are expected to increasingly disrupt Indigenous peoples' livelihoods and economies, including agriculture and agroforestry, fishing, recreation, and tourism. Adverse impacts on subsistence activities have already been observed. As climate changes continue, adverse impacts on culturally significant species and resources are expected to result in negative physical and mental health effects. Throughout the United States, climate-related impacts are causing some Indigenous peoples to consider or actively pursue community relocation as an adaptation strategy, presenting challenges associated with maintaining cultural and community continuity. While economic, political, and infrastructure limitations may affect these communities' ability to adapt, tightly knit social and cultural networks present opportunities to build community capacity and increase resilience. Many Indigenous peoples are taking steps to adapt to climate change impacts structured around self-determination and traditional knowledge, and some tribes are pursuing mitigation actions through development of renewable energy on tribal lands.

Ecosystems and Ecosystem Services

Ecosystems and the benefits they provide to society are being altered by climate change, and these impacts are projected to continue. Without substantial and sustained reductions in global greenhouse gas emissions, transformative impacts on some ecosystems will occur; some coral reef and sea ice ecosystems are already experiencing such transformational changes.

Many benefits provided by ecosystems and the environment, such as clean air and water, protection from coastal flooding, wood and fiber, crop pollination, hunting and fishing, tourism, cultural identities, and more will continue to be degraded by the impacts of climate change. Increasing wildfire frequency, changes in insect and disease outbreaks, and other stressors are expected to decrease the ability of U.S. forests to support economic activity, recreation, and subsistence activities. Climate change has already had observable impacts on

biodiversity, ecosystems, and the benefits they provide to society. These impacts include the migration of native species to new areas and the spread of invasive species. Such changes are projected to continue, and without substantial and sustained reductions in global greenhouse gas emissions, extinctions and transformative impacts on some ecosystems cannot be avoided in the long term. Valued aspects of regional heritage and quality of life tied to ecosystems, wildlife, and outdoor recreation will change with the climate, and as a result, future generations can expect to experience and interact with the natural environment in ways that are different from today. Adaptation strategies, including prescribed burning to reduce fuel for wildfire, creation of safe havens for important species, and control of invasive species, are being implemented to address emerging impacts of climate change. While some targeted response actions are underway, many impacts, including losses of unique coral reef and sea ice ecosystems, can only be avoided by significantly reducing global emissions of carbon dioxide and other greenhouse gases.

Agriculture

Rising temperatures, extreme heat, drought, wildfire on rangelands, and heavy downpours are expected to increasingly disrupt agricultural productivity in the United States. Expected increases in challenges to livestock health, declines in crop yields and quality, and changes in extreme events in the United States and abroad threaten rural livelihoods, sustainable food security, and price stability.

Climate change presents numerous challenges to sustaining and enhancing crop productivity, livestock health, and the economic vitality of rural communities. While some regions (such as the Northern Great Plains) may see conditions conducive to expanded or alternative crop productivity over the next few decades, overall, yields from major U.S. crops are expected to decline as a consequence of increases in temperatures and possibly changes in water availability, soil erosion, and disease and pest outbreaks. Increases in temperatures during the growing season in the Midwest are projected to be the largest contributing factor to declines in the productivity of U.S. agriculture. Projected increases in extreme heat conditions are expected to lead to further heat stress for livestock, which can result in large economic losses for producers. Climate change is also expected to lead to large-scale shifts in the availability and prices of many agricultural products across the world, with corresponding impacts on U.S. agricultural producers and the U.S. economy. These changes threaten future gains in commodity crop production and put rural livelihoods at risk. Numerous adaptation strategies are available to cope with adverse impacts of climate variability and change on agricultural production. These include altering what is produced, modifying the inputs used for production, adopting new technologies, and adjusting management strategies. However, these strategies have limits under severe climate change impacts and would require sufficient long- and short-term investment in changing practices.

Infrastructure

Our Nation's aging and deteriorating infrastructure is further stressed by increases in heavy precipitation events, coastal flooding, heat, wildfires, and other extreme events, as well as changes to average precipitation and temperature. Without adaptation, climate change will continue to degrade infrastructure performance over the rest of the century, with the potential for cascading impacts that threaten our economy, national security, essential services, and health and well-being.

Climate change and extreme weather events are expected to increasingly disrupt our Nation's energy and transportation systems, threatening more frequent and longer-lasting power outages, fuel shortages, and service disruptions, with cascading impacts on other critical sectors. Infrastructure currently designed for historical climate conditions is more vulnerable to future weather extremes and climate change. The continued increase in the frequency and extent of high-tide flooding due to sea level rise threatens America's trillion-dollar coastal property market and public infrastructure, with cascading impacts to the larger economy. In Alaska, rising temperatures and erosion are causing damage to buildings and coastal infrastructure that will be costly to repair or replace, particularly in rural areas; these impacts are expected to grow without adaptation. Expected increases in the severity and frequency of heavy precipitation events will affect inland infrastructure in every region, including access to roads, the viability of bridges, and the safety of pipelines. Flooding from heavy

rainfall, storm surge, and rising high tides is expected to compound existing issues with aging infrastructure in the Northeast. Increased drought risk will threaten oil and gas drilling and refining, as well as electricity generation from power plants that rely on surface water for cooling. Forward-looking infrastructure design, planning, and operational measures and standards can reduce exposure and vulnerability to the impacts of climate change and reduce energy use while providing additional near-term benefits, including reductions in greenhouse gas emissions.

Oceans & Coasts

Coastal communities and the ecosystems that support them are increasingly threatened by the impacts of climate change. Without significant reductions in global greenhouse gas emissions and regional adaptation measures, many coastal regions will be transformed by the latter part of this century, with impacts affecting other regions and sectors. Even in a future with lower greenhouse gas emissions, many communities are expected to suffer financial impacts as chronic high-tide flooding leads to higher costs and lower property values.

Rising water temperatures, ocean acidification, retreating arctic sea ice, sea level rise, high-tide flooding, coastal erosion, higher storm surge, and heavier precipitation events threaten our oceans and coasts. These effects are projected to continue, putting ocean and marine species at risk, decreasing the productivity of certain fisheries, and threatening communities that rely on marine ecosystems for livelihoods and recreation, with particular impacts on fishing communities in Hawai'i and the U.S.-Affiliated Pacific Islands, the U.S. Caribbean, and the Gulf of Mexico. Lasting damage to coastal property and infrastructure driven by sea level rise and storm surge is expected to lead to financial losses for individuals, businesses, and communities, with the Atlantic and Gulf Coasts facing above-average risks. Impacts on coastal energy and transportation infrastructure driven by sea level rise and storm surge have the potential for cascading costs and disruptions across the country. Even if significant emissions reductions occur, many of the effects from sea level rise over this century—and particularly through mid-century—are already locked in due to historical emissions, and many communities are already dealing with the consequences. Actions to plan for and adapt to more frequent, widespread, and severe coastal flooding, such as shoreline protection and conservation of coastal ecosystems, would decrease direct losses and cascading impacts on other sectors and parts of the country. More than half of the damages to coastal property are estimated to be avoidable through well-timed adaptation measures. Substantial and sustained reductions in global greenhouse gas emissions would also significantly reduce projected risks to fisheries and communities that rely on them.

Tourism and Recreation

Outdoor recreation, tourist economies, and quality of life are reliant on benefits provided by our natural environment that will be degraded by the impacts of climate change in many ways.

Climate change poses risks to seasonal and outdoor economies in communities across the United States, including impacts on economies centered around coral reef-based recreation, winter recreation, and inland water-based recreation. In turn, this affects the well-being of the people who make their living supporting these economies, including rural, coastal, and Indigenous communities. Projected increases in wildfire smoke events are expected to impair outdoor recreational activities and visibility in wilderness areas. Declines in snow and ice cover caused by warmer winter temperatures are expected to negatively impact the winter recreation industry in the Northwest, Northern Great Plains, and the Northeast. Some fish, birds, and mammals are expected to shift where they live as a result of climate change, with implications for hunting, fishing, and other wildlife-related activities. These and other climate-related impacts are expected to result in decreased tourism revenue in some places and, for some communities, loss of identity. While some new opportunities may emerge from these ecosystem changes, cultural identities and economic and recreational opportunities based around historical use of and interaction with species or natural resources in many areas are at risk. Proactive management strategies, such as the use of projected stream temperatures to set priorities for fish conservation, can help reduce disruptions to tourist economies and recreation.

The full Fourth National Climate Assessment, Volumes I and II, can be accessed [here](#).

Management of the Colorado River: Water Allocation, Drought, and the Federal Role

Pervaze A. Sheikh and Charles V. Stern

The Colorado River Basin covers more than 246,000 square miles in seven U.S. states (Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California) and Mexico. Pursuant to federal law, the Bureau of Reclamation (part of the Department of the Interior) manages much of the basin's water supplies. Colorado River water is used primarily for agricultural irrigation and municipal and industrial (M&I) uses, but it also is important for power production, fish and wildlife, and recreational uses.

In recent years, consumptive uses of Colorado River water have exceeded natural flows. This causes an imbalance in the basin's available supplies and competing demands. A drought in the basin dating to 2000 has raised the prospect of water delivery curtailments and decreased hydropower production, among other things. In the future, observers expect that increasing demand for supplies, coupled with the effects of climate change, will further increase the strain on the basin's limited water supplies.

River Management

The *Law of the River* is the commonly used shorthand for the multiple laws, court decisions, and other documents governing Colorado River operations. The foundational document of the Law of the River is the Colorado River Compact of 1922. Pursuant to the compact, the basin states established a framework to

apportion the water supplies between the Upper and Lower Basins of the Colorado River, with the dividing line between the two basins at Lee Ferry, AZ (near the Utah border). The Upper and Lower Basins each were allocated 7.5 million acre-feet (MAF) annually under the Colorado River Compact; an additional 1.5 MAF in annual flows was made available to Mexico under a 1944 treaty. Future agreements and court decisions addressed numerous other issues (including intrastate allocations of flows), and subsequent federal legislation provided authority and funding for federal facilities that allowed users to develop their allocations. A Supreme Court ruling also confirmed that Congress designated the Secretary of the Interior as the *water master* for the Lower Basin, a role in which the federal government manages the delivery of all water below Hoover Dam.

Reclamation and basin stakeholders closely track the status of two large reservoirs—Lake Powell in the Upper Basin and Lake Mead in the Lower Basin—as an indicator of basin storage conditions. Under recent guidelines, dam releases from these facilities are tied to specific water storage levels. For Lake Mead, the first tier of “shortage,” under which Arizona's and Nevada's allocations would be decreased, would be triggered if Lake Mead's January 1 elevation is expected to fall below 1,075 feet above mean sea level. As of early 2019, Reclamation projected that there was a 69% chance of a shortage condition at Lake Mead in 2020; there was also a lesser chance of Lake Powell reaching critically low levels. Improved hydrology in early 2019 may decrease the chances of shortage in the immediate future.

Sheikh and Stern are specialists in natural resources policy with the Congressional Research Service. This article is adapted from the original, longer report of the same title.

Water Storage and Operations

Due to the basin's large water storage projects, basin water users are able to store as much as 60 MAF, or about four times the Colorado River's annual flows. Thus, storage and operations in the basin receive considerable attention, particularly at the basin's two largest dams and their storage reservoirs: Glen Canyon Dam/Lake Powell in the Upper Basin (26.2 MAF of storage capacity) and Hoover Dam/Lake Mead in the Lower Basin (26.1 MAF). The status of these projects is of interest to basin stakeholders and observers and is monitored closely by Reclamation.

Glen Canyon Dam, completed in 1963, provides the linchpin for Upper Basin storage and regulates flows from the Upper Basin to the Lower Basin, pursuant to the Colorado River Compact. It also generates approximately 5 billion kilowatt hours (KWh) of electricity per year, which the Western Area Power Administration (WAPA) supplies to 5.8 million customers in Upper Basin States.¹ Other significant storage in the Upper Basin includes the initial "units" of the CRSP: the Aspinall Unit in Colorado (including Blue Mesa, Crystal, and Morrow Point dams on the Gunnison River, with combined storage capacity of more than 1 MAF),² the Flaming Gorge Unit in Utah (including Flaming Gorge Dam on the Green River, with a capacity of 3.78 MAF), and the Navajo Unit in New Mexico (including Navajo Dam on the San Juan River, with a capacity of 1 MAF). The Upper Basin is also home to 16 "participating" projects which are authorized to use water for irrigation, municipal and industrial uses, and other purposes.³

In the Lower Basin, Hoover Dam, completed in 1936, provides the majority of the Lower Basin's storage and generates about 4.2 billion KWh of electricity per year for customers in California, Arizona, and Nevada.⁴ Also important for Lower Basin Operations are Davis Dam/Lake Mohave, which regulates flows to Mexico under the 1944 Treaty, and Parker Dam/Lake Havasu, which impounds water for diversion into the Colorado River Aqueduct (thereby allowing for deliveries to urban areas in southern California) and CAP (allowing for diversion to users in Arizona). Further downstream on the Arizona/California border, Imperial Dam (a diversion dam) diverts Colorado River water to the All-American Canal for use in California's Imperial and Coachella Valleys.

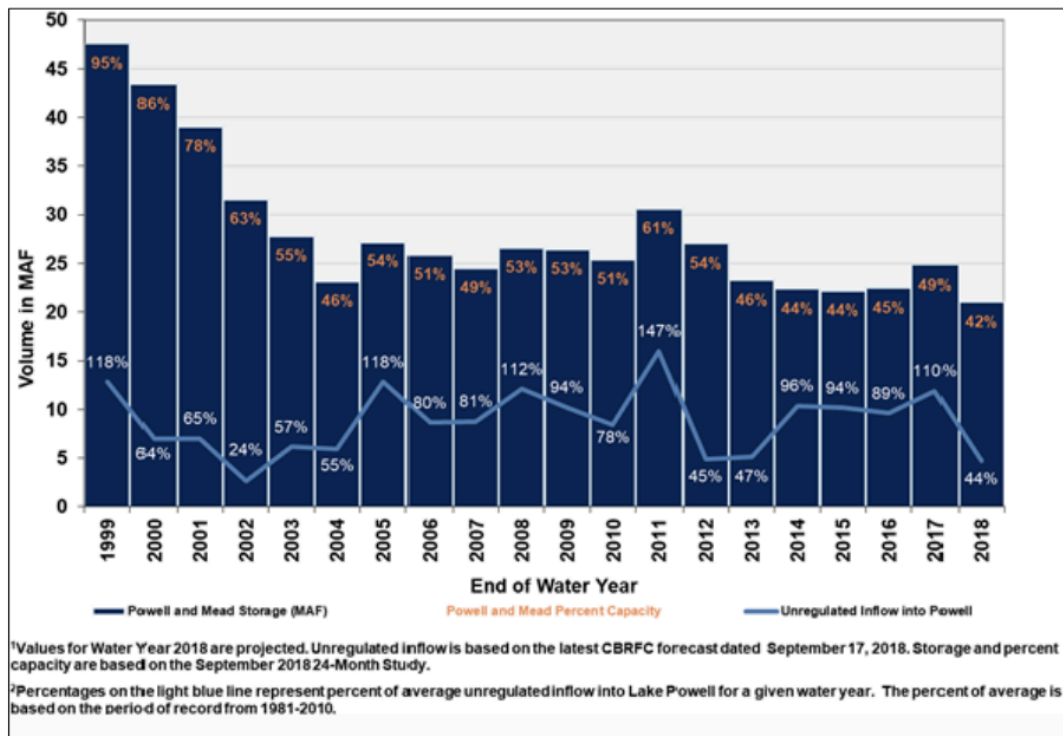
Drought and the Supply/Demand Imbalance in the Colorado River Basin

When the Colorado River Compact was originally approved, it was assumed based on the historical record that average annual flows on the river were 16.4 MAF per year.⁵ According to Reclamation data, from 1906 to 2018, observed natural flows on the river at Lee Ferry, AZ—the common point of measurement for observed basin flows—averaged 14.8 MAF annually.⁶ Natural flows from 2000 to 2018 (i.e., during the ongoing drought) averaged considerably less than that—12.4 MAF annually.⁷ While natural flows have trended down, consumptive use in the basin has grown and has regularly exceeded natural flows since 2000. From 1971 to 2015, average total consumptive use grew from 13 MAF to over 15 MAF annually.⁸ Combined, the two trends have caused a significant drawdown of basin storage levels (**Figure 1**).

From 2009 to 2015, the largest consumptive water use occurred in the Lower Basin (7.5 MAF per year), while Upper Basin consumptive use averaged about 3.8 MAF annually.⁹ Use of Treaty water by Mexico (1.5 MAF per year) and evaporative loss from reservoirs (approximately 2 MAF per year) in both basins also factored significantly into total basin consumptive use.¹⁰ Notably, consumptive use in the Lower Basin, combined with mandatory releases to Mexico, regularly exceeds the mandatory 8.23 MAF per year that must be released from the Upper Basin to the Lower Basin and Mexico pursuant to Reclamation requirements.¹¹ This imbalance between Lower Basin inflows and use, known as the *structural deficit*, causes additional stress on basin storage.

The current drought in the basin has included some of the lowest flows on record.¹² According to Reclamation, the 19-year period from 2000 to 2018 was the driest period in more than 100 years of record keeping.¹³ Observers have pointed out that flows in some recent years have been lower than would be expected given the amount of precipitation that has occurred, and have noted that warmer temperatures appear to be a significant

Figure 1. Lake Powell and Lake Mead Storage and Inflows
(as of fall 2018)



Source: Bureau of Reclamation, 2018 Congressional Presentation on Drought Contingency Plans.

Notes: Water year 2018 values represent projections as of September 2018. Percentage of average annual unregulated inflow into Lake Powell is based on the period of record from 1981-2010, and is generally seen as a measure of basin hydrologic conditions.

contributor to these diminished flows.¹⁴ Based on these and other observations, some have argued that Colorado River flows are unlikely to return to 20th century averages, and that future water supply risk is high.¹⁵

2012 Reclamation Study

A 2012 study by Reclamation projected a long-term imbalance in supply and demand in the Colorado River Basin.¹⁶ In the study, Reclamation noted that the basin had thus far avoided serious impacts on water supplies due to the significant storage within the system, coupled with the fact that some Upper Basin states have yet to fully develop the use of their allocations.¹⁷ However, Reclamation projected that in the coming half century, flows would decrease by an average of 9% at Lee Ferry and drought would increase in frequency and duration.¹⁸ At the same time, Reclamation projected that demand for basin water supplies would increase, with annual consumptive use projected to rise from 15 MAF to 18.1-20.4 MAF by 2050, depending on population growth.¹⁹ A range of 64%-76% of the growth in demand was expected to come from increased M&I demand.²⁰

Reclamation's 2012 study also posited several potential ways to alleviate future shortages in the basin, such as alternative water supplies, demand management, drought action plans, water banking, and water transfer/markets. Some of these options already are being pursued. In particular, some states have become increasingly active in banking unused Colorado River surface water supplies, including through groundwater banks or storage of unused surface waters in Lake Mead (see below section, "2007 Interim Guidelines").

2019 Drought Contingency Plans

Ongoing drought conditions and the potential for water supply shortages prompted discussions and negotiations focused on how to conserve additional basin water supplies. After several years of negotiations, on March 19, 2019, Reclamation and the Colorado River Basin states finalized DCPs for both the Upper Basin and the Lower Basin. These plans required final authorization by Congress to be implemented. Following House and Senate hearings on the DCPs in early April, on April 16, 2019, Congress authorized the DCP agreements in the Colorado River Drought Contingency Plan Authorization Act (P.L. 116-14). Each of the basin-level DCPs is discussed below in more detail.

Upper Basin Drought Contingency Plan

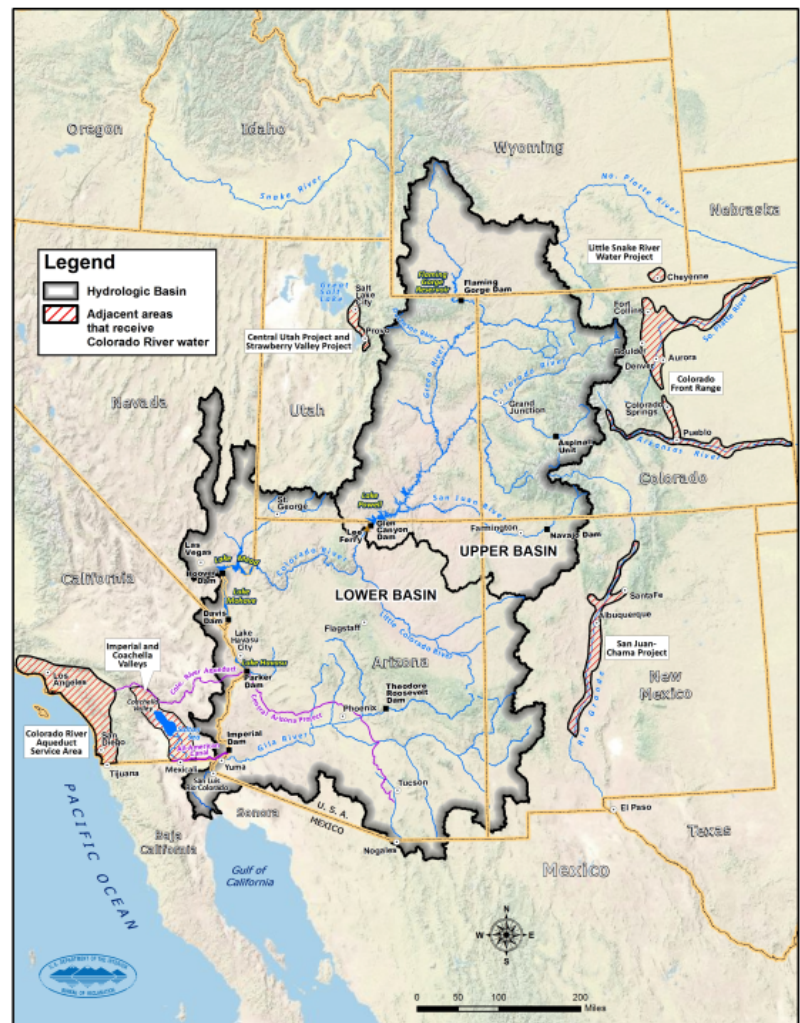
The Upper Basin DCP aims to protect against Lake Powell reaching critically low elevations; it also authorizes storage of conserved water in the Upper Basin that could help establish the foundation for a water use reduction effort (i.e., a “Demand Management Program”) that may be developed in the future.²¹ Under the Upper Basin DCP, the Upper Basin states agree to operate system units to keep the surface of Lake Powell above 3,525 ft, which is 35 ft above the minimum elevation needed to run the dam’s hydroelectric plant. Other large Upper Basin reservoirs (e.g., Navajo Reservoir, Blue Mesa Reservoir, and Flaming Gorge Reservoir) would be operated to protect the targeted Lake Powell elevation, potentially through drawdown of their own storage. If established by the states, an Upper Basin DCP Demand Management Program would likely entail willing seller/buyer agreements allowing for temporary paid reductions in water use that would provide for more storage volume in Lake Powell.

Reclamation and other observers have stated their belief that these efforts will significantly decrease the risk of Lake Powell’s elevation falling below 3,490 ft, an elevation at which significantly reduced hydropower generation is possible.²²

Lower Basin Drought Contingency Plan

The Lower Basin DCP is designed to require Arizona, California, and Nevada to curtail use and thereby contribute additional water to Lake Mead storage at predetermined “trigger” elevations, while also creating additional flexibility to incentivize voluntary conservation of water to be stored in Lake Mead, thereby increasing lake levels. Under the DCP, Nevada and Arizona (which were already set to have their supplies curtailed beginning at 1,075 ft under the 2007 Interim Guidelines) are to contribute additional supplies to maintain higher lake levels (i.e., beyond previous commitments). The reductions of supply would reach their maximums when reservoir

Figure 2. Colorado River Basin and Areas that Import Colorado River Water



Source: Bureau of Reclamation, *Colorado River Basin Supply and Demand Study*, 2012.

levels drop below 1,045 ft. At the same time, the Lower Basin DCP would, for the first time, include commitments for delivery cutbacks by California. These cutbacks would begin with 200,000 AF (4.5%) in reductions at Lake Mead elevations of 1,040-1,045 ft, and would increase to as much as 350,000 AF (7.9%) at elevations of 1,025 ft or lower.

The curtailments in the Lower Basin DCP are in addition to those agreed to under the 2007 Interim Guidelines and under Minute 323 with Mexico. Specific and cumulative reductions are shown in **Table 1**. In addition to the state-level reductions, under the Lower Basin DCP, Reclamation also would agree to pursue efforts to add 100,000 AF or more of system water within the basin. Some of the largest and most controversial reductions under the Lower Basin DCP would occur in Arizona, where pursuant to previous changes under the 2004 AWSA, a large group of agricultural users would face major cutbacks to their CAP water supplies.

Reclamation has noted that the Lower Basin DCP significantly decreases the chance of Lake Mead elevations falling below 1,020 ft, which would be a critically low level.²³ Some parties have pointed out that although the DCP is unlikely to prevent a shortage from being declared at 1,075 ft, it would slow the rate at which the lake recedes thereafter.²⁴ Combined with the commitments from Mexico, total planned cutbacks under shortage scenarios (i.e., all commitments to date, combined) would reduce Lower Basin consumptive use by 241,000 AF to 1.375 MAF per year, depending on Lake Mead's elevation.²⁵

Drought Contingency Plan Opposition

Although the DCPs and the related negotiations were widely praised, some expressed concerns related to the implementation of the DCPs as they relate to federal and state environmental laws. Most Colorado River contractors supported the agreements, but one major basin contractor, Imperial Irrigation District (IID, a major holder of Colorado River water rights in Southern California), did not approve the DCPs. IID has argued that the

Table 1. Lower Basin Water Curtailment Volumes Under Existing Agreements
(values in thousands of acre-feet)

Lake Mead Elevation (ft)	2007 Interim Shortage Guidelines		Minute 323 Delivery Reductions	DCP Curtailment			Binational Water Scarcity Conting. Plan	Total Volume of Curtailment (% of Colorado River Apportionment)				
	AZ	NV	Mexico	AZ	NV	CA	Mexico	AZ	NV	CA	Lower Basin	Mexico
1,090 - >1,075	0	0	0	192	8	0	41	192 (6.8%)	8 (2.6%)	0 (0%)	200	41
1,075 - >1,050	320	13	50	192	8	0	30	512 (18.2%)	21 (7%)	0 (0%)	533	80
1,050 - >1,045	400	17	70	192	8	0	34	592 (21.1%)	25 (8.3%)	0 (0%)	617	104
1,045 - >1,040	400	17	70	240	10	200	76	640 (22.8%)	27 (9.0%)	200 (4.5%)	867	146
1,040 - >1,035	400	17	70	240	10	250	84	640 (22.8%)	27 (9.0%)	250 (5.6%)	917	154
1,035 - >1,030	400	17	70	240	10	300	92	640 (22.8%)	27 (9.0%)	300 (6.8%)	967	162
1,030 - 1,025	400	17	70	240	10	350	101	640 (22.8%)	27 (9.0%)	350 (7.9%)	1,017	171
<1,025	480	20	125	240	10	350	150	720 (22.8%)	30 (10.0%)	350 (7.9%)	1,100	275

Sources: Table by CRS, using data in the 2007 Interim Shortage Guidelines, Minute 323 between Mexico and the United States, the *Draft Lower Basin Drought Contingency Plan*, and the Binational Water Scarcity Contingency Plan in Minute 323 between Mexico and the United States.

DCPs will further degrade the Salton Sea, a shrinking and ecologically degraded water body in southern California that relies on drainage flows from lands irrigated using Colorado River water.²⁶ Following enactment of the DCPs, IID filed suit in state court alleging that state approval of the DCPs violated the California Environmental Quality Act.²⁷ Others have questioned whether federal implementation of the DCPs without a new or supplemental Environmental Impact Statement might violate federal law, such as NEPA.²⁸

Issues for Congress

Funding and Oversight of Existing Facilities and Programs

The principal role of Congress as it relates to storage facilities on the Colorado River is funding

and oversight of facility operations, construction, and programs to protect and restore endangered species (e.g., Glen Canyon Dam Adaptive Management Program and the Upper Colorado River Endangered Fish Program). In the Upper Basin, Colorado River facilities include the 17 active participating units in the Colorado River Storage Projects, as well as the Navajo-Gallup Water Supply Project. In the Lower Basin, major facilities include the Salt River Project and Theodore Roosevelt Dam, Hoover Dam and All-American Canal, Yuma and Gila Projects, Parker-Davis Project, Central Arizona Project, and Robert B. Griffith Project (now Southern Nevada Water System).

Congressional appropriations in support of Colorado River projects and programs typically account for a portion of overall project budgets. For example, the Lower Colorado Region's FY2017 operating budget was \$517 million; \$119.8 million of this total was provided by discretionary appropriations, and the remainder of funding came from power revenues (which are made available without further appropriation) and nonfederal partners.²⁹ In recent years, Congress has also authorized and appropriated funding that has targeted the Colorado River Basin in general (i.e., the Pilot System Conservation Plan). Congress may choose to extend or amend these and other authorities specific to the basin.

While discretionary appropriations for the Colorado River are of regular interest to Congress, Congress may also be asked to weigh in on Colorado River funding that is not subject to regular appropriations. For instance, in the coming years, the Lower Colorado River Basin Development Fund is projected to face a decrease in revenues³⁰ and may thus have less funding available for congressionally established funding priorities for the Development Fund.

Indian Water Rights Settlements and Plans for New and Augmented Water Storage

Congress has previously approved Indian water rights settlements associated with more than 2 MAF of tribal diversion rights on the Colorado River. Only a portion of this water has been developed. Congress likely will face the decision of whether to fund development of previously authorized infrastructure associated with Indian water rights settlements in the Colorado River Basin. For example, the ongoing Navajo-Gallup Water Supply Project is being built to serve the Jicarilla Apache Nation, the Navajo Nation, and the City of Gallup, New Mexico.³¹ Congress may also be asked to consider new settlements that may result in tribal rights to more Colorado River water. For example, in the 116th Congress, H.R. 244 would authorize the Navajo Nation Water Settlement in Utah.

In addition to development of new tribal water supplies, some states in the Upper Basin have indicated their intent to further develop their Colorado River water entitlements. For example, in the 115th Congress, Section 4310 of America's Water Infrastructure Act (P.L. 115-270) authorized the Secretary of the Interior to enter into an agreement with the State of Wyoming whereby the state would fund a project to add erosion control to Fontenelle Reservoir in the Upper Basin. The project would allow the state to potentially utilize an additional 80,000 acre feet of water storage on the Green River, a tributary of the Colorado River.

Drought Contingency Plan Implementation

Congress may remain interested in implementation of the DCPs, including their success or failure at stemming further Colorado River cutbacks and the extent to which the plans comply with federal environmental laws such as NEPA. Similarly, Congress may be interested in the overall hydrologic status of the Colorado River Basin, as well as future efforts to plan for increased demand in the basin and stretch limited basin water supplies.

The full report, “Management of the Colorado River: Water Allocations, Drought, and the Federal Role” can be found here: <https://crsreports.congress.gov/product/pdf/R/R45546>.

References:

¹ Bureau of Reclamation, Upper Colorado Region, “Glen Canyon Unit,” accessed February 21, 2019, <https://www.usbr.gov/uc/rm/crsp/gc/>.

² The Curecanti Unit was renamed the Aspinall Unit in 1980 in honor of U.S. Representative Wayne N. Aspinall of Colorado.

³ In total, 16 of the 22 Upper Basin projects authorized as part of CRSP have been developed. (The five remaining projects were determined by Reclamation to be infeasible.) For a complete list of projects, see <https://www.usbr.gov/uc/rm/crsp/index.html>.

⁴ Bureau of Reclamation, “Hoover Dam Frequently Asked Questions and Answers,” accessed February 21, 2019, Bureau of Reclamation, Upper Colorado Region, Glen Canyon Unit, accessed February 21, 2019, <https://www.usbr.gov/uc/rm/crsp/gc/>.

⁵ National Research Council, Committee on the Scientific Bases of Colorado River Basin Water Management, Water Science and Technology Board, Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability, 2007, at <https://www.nap.edu/read/11857/chapter/1>

⁶ For dataset on natural flows and more information, see Bureau of Reclamation, Lower Colorado River Operations, “General Modeling Information,” accessed January 17, 2018, at <https://www.usbr.gov/lc/region/g4000/riverops/model-info.html>.

⁷ Bureau of Reclamation Flow Data, 1906-2018.

⁸ 1971-2008 consumptive use data based on data in Reclamation 2012 Supply/Demand Study, Technical Report C, p. C-6. Analysis of 2009-2015 Upper Basin consumptive use data by CRS, based on data in Provisional Bureau of Reclamation Consumptive Uses and Losses Reports for 2006-2010 and 2011-2015. Analysis of 2009-2015 Lower Basin consumptive use data by CRS, based on Bureau of Reclamation Colorado River Water Accounting and Use Reports for 2009-2015. Hereinafter, references to consumptive use data analysis based on these four reports are referred to collectively as “CRS Analysis of Colorado River Consumptive Use Data.”

⁹ CRS Analysis of Colorado River Consumptive Use Data.

¹⁰ CRS Analysis of Colorado River Consumptive Use Data.

¹¹ The minimum average annual volume that the Upper Basin must release is 8.23 MAF; this includes Upper Basin releases of 75 MAF over any 10-year period (i.e., an average of 7.5 MAF per year), plus half of the water due to Mexico (i.e., 0.75 MAF).

¹² The 2000-2018 period included the second, third, fourth, and fifth lowest years on record.

¹³ U.S. Bureau of Reclamation, Annual Operating Plan for Colorado River Reservoirs, 2019, September 10, 2018, p. 8. Hereinafter “Reclamation 2019 Draft AOP.”

¹⁴ Woodhouse, C.A., G.T. Pederson, and K. Horino, et al., “Increasing influence of air temperature on upper Colorado River streamflow,” *Geophysical Research Letters*, vol. 43 (2016), pp. 2174-2181.

¹⁵ Udall, B. and J. Overpeck, “The twenty-first century Colorado River hot drought and implications for the future,” *Water Resources Research*, vol. 53 (February 17, 2017), pp. 2404-2418.

¹⁶ Reclamation 2012 Supply/Demand Study.

¹⁷ This is largely due to a lack of development in Wyoming (which uses approximately 500,000 acre-feet of its 1 MAF in Colorado River supplies) and Utah (which uses approximately 800,000 acre-feet of its 1.7 MAF in supplies).

¹⁸ Reclamation 2012 Supply/Demand Study, p. 7.

¹⁹ Reclamation 2012 Supply/Demand Study, p. 8. Population growth in central Arizona and on the Front Range of Colorado is expected to comprise the majority of basin population increases.

²⁰ Reclamation 2012 Supply/Demand Study, Technical Report C, p. C-22. The majority of this demand increase was assumed to come from Central Arizona and the Front Range in Colorado.

²¹ Prior to the drought contingency plan (DCPs), such a mechanism existed for the Lower Basin but not for the Upper Basin

²² Bureau of Reclamation, “Presentation to Congressional Staff on Draft Drought Contingency Plans,” October 16, 2018. Hereinafter “2018 Reclamation DCP Presentation.”

²³ 2018 Reclamation DCP Presentation. Currently, there are no agreed-upon curtailment levels governing operations below 1,020 ft, thus that level represents an unknown and likely more severe level of curtailment that would affect more users than those affected under the 2007 guidelines.

²⁴ Tom Buschatzke, Arizona Department of Water Resources Director, and Ted Cooke, Central Arizona Project General Manager, “The DCP Makes CO River Delivery Shortfalls Less Painful, but It Doesn’t Make Them Go Away,” Arizona Department of Water Resources, September 5, 2018, at <https://new.azwater.gov/news/articles/2018-05-09>.

²⁵ For a summary of the curtailments that add up to this amount, see “1,090->1,075” row of Table 1.

²⁶ IID, the largest water rights holder on the Colorado River, did not approve the Lower Basin DCP. While there were no formal requirements for IID delivery curtailments under the Lower Basin DCP (other contractors have committed to implementing California’s curtailments), IID objected to the lack of commitments for Salton Sea restoration under the plans. For more information, see CRS In Focus IF11104, Salton Sea Management and Restoration Efforts, by Pervaze A. Sheikh and Charles V. Stern.

²⁷ IID, “Salton Sea Is Focus of IID’s Legal Challenge to Drought Contingency Plan,” press release, April 17, 2019, <https://www.iid.com/Home/Components/News/News/685/30?backlist=%2f>.

²⁸ Jeremy Jacobs, “NEPA Looms Over Drought Plan Enthusiasm,” *Greenwire*, April 30, 2019. <https://www.eenews.net/stories/1060246711>.

²⁹ Bureau of Reclamation, Lower Colorado Regional Report, FY2017, at <https://www.usbr.gov/lc/docs/LCRegionReportFY17.pdf>.

³⁰ The projected decrease in revenues is due to, among other factors, the decommissioning of the Navajo Generating Station (whose receipts are one source of incoming revenue accruing to the fund).

³¹ This project was authorized in the Omnibus Public Land Management Act of 2009 (P.L. 111-11), Title X, Part III.

Announcements

Renewable Natural Resources Foundation

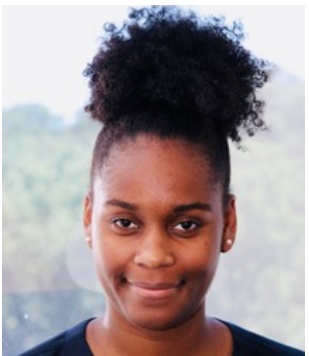
New RNRF Staff Members



Madeline Voitier has joined RNRF's staff as Senior Program Manager. She received a Bachelor's degree in history at Louisiana State University in 2012, and a Juris Doctorate from Loyola University New Orleans College of Law in 2017, with a certificate in Environmental Law.

Before joining RNRF, Voitier worked at Oceana, first as Law Fellow for the Legal Department and later as the Policy and Legal Specialist for the Offshore Drilling Campaign. During her time with Oceana, she engaged in every aspect of Oceana's advocacy campaigns and gained valuable experience working with the policy, field, communications and science teams. In addition, Voitier researched and wrote a comprehensive report analyzing U.S. offshore energy policy released in April 2019.

She works with RNRF committees 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. She also will have editorial responsibilities for the Renewable Resources Journal, Renewable Resources Report (RNRF's blog) and RNRF's website.



Sydney Austin has joined RNRF's staff as a summer program associate. She is currently a rising junior at George Washington University (GWU) where she is pursuing a degree in environmental studies and economics. At GWU, Austin has distinguished herself academically, having been named a Stephen Joel Trachtenberg scholar. She previously interned at the Bermuda Department of Environment and Natural Resources, where she assisted in oceanic research.

Planning for Coastal Inland Resilience: Keeping Toxic Substances Out of the Water and Avoiding Unwise Development

On June 13, 2019, the Renewable Natural Resources Foundation (RNRF) presented a meeting titled "Planning for Coastal Inland Resilience: Keeping Toxic Substances Out of the Water and Avoiding Unwise Development," hosted by the American Society of Civil Engineers at its Capitol Hill office in D.C. Speakers included Pete Harrison with Earthjustice and Jeff Peterson formerly with the Environmental Protection Agency's (EPA) Office of Water and the Council on Environmental Quality (CEQ). The speakers discussed issues and challenges of planning and developing coastal communities that are at risk from increasingly frequent and devastating storms. In particular, the speakers highlighted the weaknesses exposed by Hurricane Florence, which devastated communities of the coastal Carolinas.



Pete Harrison, a staff attorney with Earthjustice and an expert on coal pollution, spoke about dangers that coal ash poses to human and environmental health. He also described the regulatory and legal challenges of mitigating those dangers.

Coal ash is the substance that is left over after coal is burned. Coal ash is typically stored in large unlined ponds called surface impoundments and in landfills. These unlined impoundments usually are located next to coal-fired power plants in flood-prone areas adjacent to waterways.

Coal ash is problematic because it contains numerous contaminants that pose environmental and health risks to wildlife and humans. When coal is burned the contents are further concentrated. These contents include heavy metals such as arsenic, chromium, lead and selenium. Selenium in particular is especially toxic to aquatic life.

In the United States, 110 million tons of coal ash are generated every year and much of it is stored in giant impoundment ponds. The current tally of coal ash sites is roughly 1,400 in 47 states. Harrison noted that this estimate is likely far too low since many older coal ash sites have been forgotten and are uncounted. The majority of these sites are located in the Southeast and the Ohio River Valley and are typically located in floodplains, or flood-prone areas.

Regarding regulation of coal ash impoundments in floodplains, Harrison noted that the Resource Conservation and Recovery Act (RCRA) contains a provision that could apply to coal ash since it applies to all solid waste dumps (40 C.F.R. 257.3-1). Harrison explained that this RCRA provision is rarely enforced because the language is arguably vague and difficult to implement.

In 2015, the EPA finalized a rule that specifically applied to coal ash impoundments and coal ash landfills. Harrison pointed out that this 2015 regulation excludes any coal ash impoundments or landfills at inactive coal-fired power plants. Meaning, power plants not generating electricity after 2015 are not subject to the regulation. Additionally, Harrison explained that the 2015 rule can only be enforced through lawsuits, either by a citizen or a state, or by state adoption of the rule. A state may adopt the rule and codify it under state law to be enforced by the state. When asked about state regulation of coal ash, Harrison noted that the Illinois legislature had recently passed such legislation. For more information about the Illinois action [click here](#).

Harrison illustrated the dangers of siting coal ash impoundments in floodplains by describing the events that took place at the Duke Energy Sutton Plant on the Cape Fear River, in North Carolina. In 2018, Hurricane Florence brought the most severe flooding in the river's history. As a result, the flood waters broke through the dams surrounding the Sutton Plant impoundments and released several thousand tons of coal ash into the surrounding waterways, wetlands and a popular nearby fishing lake, Lake Sutton. Harrison noted that effective cleanup of coal ash contamination was difficult and that Duke Energy did not recover any of what was spilled during Hurricane Florence.

Duke University recently released a study on the sediment in Lake Sutton that documented the presence of coal ash solids. For more information on this Duke University study [click here](#). Harrison believes that there has not been an adequate evaluation of the dangers of contaminants in Lake Sutton and that more investigation is warranted.

Harrison also discussed the potential beneficial uses for coal ash. Coal ash can be used as structural fill material in concrete for road construction projects including in roadbeds and interstate off ramps. Harrison pointed to several potential drawbacks to using coal ash this way. He noted that there are no requirements that the structural fill be monitored over time and that coal ash can be radioactive.

Overall, Harrison focused on the fact that the location of unlined coal ash impoundments in floodplains poses significant risks to human and environmental health. He observed that these risks will likely be exacerbated by more frequent and more severe storms that are predicted to occur as a result of changing climate patterns.

To access Pete Harrison's PowerPoint presentation click [here](#).



Jeff Peterson, formerly with EPA's Office of Water and CEQ, discussed the dangers posed by ignoring the risks associated with rising sea levels and intensifying natural disasters to those living along the coasts. He began his talk with a broad overview of the challenges facing American coasts due to intensifying storms, like Hurricane Florence, and discussed the obstacles of planning and developing coastal communities in the times of sea-level rise.

One critical issue with more intense storms is the resulting storm surge. As sea levels rise, storm surges will increase and push water farther inland, flooding more expansive areas. Peterson explained that not only do more extensive areas flood due to storm surges, but recent research on these intensifying storms has found that they move slower, release more precipitation and intensify more rapidly than previous storms.

Peterson noted that the latest climate models indicate that approximately one foot of sea-level rise by the year 2100 is essentially a certainty. Estimates of three feet in sea-level rise globally are also a reasonable possibility according to Peterson. The U.S. coasts, particularly the East Coast, are more vulnerable to sea level rise than the rest of the world. It has been estimated that parts of the American coasts are likely to see sea-level rise of up to 30% greater than the global average. This vulnerability is due to a combination of geography, ocean currents and land subsidence in the East Coast and Gulf of Mexico regions.

Using the three feet of sea level rise estimate, scientific studies have identified 12,000 sq. miles of current American coastline likely to be inundated by 2100. Peterson acknowledged that this estimate covers three and a half million people and hundreds of communities that will be impacted by sea-level rise. Additionally, the EPA anticipates losses of roughly \$3 trillion due to coastal storms and sea-level rise based upon current population growth and assets.

Peterson contended that current federal policies give coastal inhabitants a misimpression regarding the risks associated with living in coastal areas. Namely, he pointed to the National Flood Insurance Program and federal appropriations for disaster relief. He argues that, in effect, the flood insurance program encourages people to live in flood prone areas because the federal government covers those financial losses. Peterson emphasized that this program is not financially sustainable and is losing over \$1 billion a year. He also argued that federal disaster relief appropriations incentivize people to rebuild their damaged properties in these risky areas.

To help curb the impacts of sea-level rise, Peterson posed the following potential approaches. He proposed a long-term phase out of the flood insurance program that could take place over a 30-year period. He also suggested that Congress reevaluate its disaster relief policies and shift its emphasis to funding preemptive disaster planning rather than reactionary rebuilding post-disaster. The prospect of requiring upfront financial assurances for the decommissioning costs of properties built in coastal areas was also posited. Lastly, Peterson proposed implementation of a permit program, similar to the wetlands permitting program under the Clean Water Act, that could be instituted to determine if people should be building in these high-risk areas.

The majority of sea-level rise mitigation planning is happening at the state and local levels. Peterson advocates for significant federal government involvement in the planning process. He argues the federal government has the resources, most current science, and ability to avoid inconsistent plans among communities. Overall, Peterson emphasized that sea-level rise is not something in the distant future, it is happening now. —*Madeline Voitier, RNRF Sr. Program Mgr.*

RNRF Meeting: Deep Seabed Mineral Mining and the U.S.

On May 29, 2019, the Renewable Natural Resources Foundation (RNRF) presented a meeting titled "Deep Seabed Mineral Mining and the U.S.: Diplomatic, Legal, and Environmental Aspects," hosted by the American Geophysical Union in its newly renovated headquarters in Washington, D.C. Speakers were Greg O'Brien, U.S.

Department of State; Kerry Kehoe, U.S. National Oceanic and Atmospheric Administration; and David Diamond, U.S. Geological Survey. They described how the U.S. is participating in deliberations of the International Seabed Authority (ISA), the U.N organization that is writing the rules for exploring and exploiting mineral resources beneath the “high seas.”



Greg O'Brien, a foreign affairs officer in the State Department’s Office of Ocean and Polar Affairs, has led the U.S.’s observer delegation to the ISA since 2015, and spoke about the role of the U.S. in the rulemaking process.

Part XI of the UN Convention on the Law of the Sea (UNCLOS) defines the “Area” that the treaty has the authority to regulate. This includes all seabed, ocean floor, and subsoil outside of national jurisdictions. UNCLOS gives the ISA the authority to establish the rules and regulations governing exploration and exploitation of the resources found in the Area. Membership in the ISA mirrors signatories of UNCLOS, including 168 countries. Since the U.S. is not a party to the convention, it sends a delegation to attend meetings as an observer state.

Despite this non-member status, the U.S. has an interest in development of ISA regulations because of significant mineral resources in the Area. O’Brien stated that our main focus in our engagement is to ensure that regulations that have been developed for exploration and the regulations under development for exploitation are consistent with applicable law, particularly as reflected in the convention. If the U.S. were to ratify UNCLOS, it would be the only country with a permanent seat on the council of ISA, meaning that it would have the authority to veto any regulations or proposals counter to its interests.

Even as an observer state, the U.S. does play a role in the rulemaking process. O’Brien noted that they work closely with other delegations, usually in the margins between sessions. The secretariat, which is the primary rulemaking body of the ISA, has also reached out to the U.S. delegation informally for collaboration in developing some parts of the regulations. Recently, ISA has reached out to the Department of the Interior about the Outer Continental Shelf Lands Act and the development of its standards and guidelines. Regulation of deep seabed resource exploitation is relatively unprecedented, so there is a demand for expertise from existing regulatory frameworks. In that regard, O’Brien said that the U.S. has developed the gold standard. In the Q&A session after his talk, O’Brien noted that no public input on the process of drafting exploration or exploitation rules has been solicited by the U.S. delegation or government. Also, prospective mining contractors are providing technical expertise to the ISA because of its limited technical resources.

ISA rulemaking is very important because it is thought that the Area contains significant critical minerals, including rare-earth minerals. While they are unsure of the exact amount of resources on the deep seabed, many scientists (including some from the U.S. Geological Survey) believe that the Clarion-Clipperton Zone (CCZ), located west of Mexico and southeast of Hawaii, holds three times the amount of certain rare earth minerals than all terrestrial deposits combined.

As a party to UNCLOS, the U.S. could sponsor companies to have mining rights in the CCZ and other areas of the international deep seabed. However, the U.S. cannot currently do this, and companies will not take the risk of mining without the legal certainty that having a sponsor affords them.

O’Brien described some issues that the ISA is currently facing in its rulemaking process. First, environmental assessment and risk management are of great concern, but there is currently much that is not known about biodiversity and the environmental baseline in the Area. This dearth of information makes it far more difficult to craft effective environmental regulation. The U.S. delegation is also advocating for heightened cognizance of other uses of the deep seabed, namely underwater telecommunications cables. Since there are such cables running through the CCZ, it is important that this be considered when crafting regulations.

Royalty payments to the ISA for mining activities are also under discussion. The U.S. is helping with this process – MIT's policy research lab has been working with the ISA secretariat for two years about options for what the formula for royalties would be and when such a policy would take effect. Overall, O'Brien says, the U.S. wants ISA to adopt policies that are friendly to enterprise and place no greater regulatory burden on mining companies than current terrestrial mining regulations.



Kerry Kehoe, a federal consistency specialist in the Office for Coastal Management at NOAA, spoke about managing the Deep Sea Hard Mineral Resources Act (DSHMRA). The act established the domestic authority for regulation of deep-sea mineral mining.

DSHMRA was enacted in 1980 before the adoption of UNCLOS and the establishment of the ISA. It established the requirements for U.S. citizens engaged in exploration or mining in international waters. Mining in domestic waters is administered by the Bureau of Ocean Energy Management. DSHMRA was drafted as an interim measure pending U.S. ratification of UNCLOS. However, since UNCLOS has not been ratified, DSHMRA remains in place.

For U.S. citizens, a license is required for exploration and a permit is required for mining activities in international waters. There are numerous environmental and other compliance regulations that may apply to these activities, like the Clean Water Act, Clean Air Act, and Endangered Species Act. Presently, there are only two ongoing exploration licenses from the U.S., and both of them belong to Lockheed Martin. While these contracts are extended every five years, no permits have been issued for mining.

Kehoe continued by discussing the interests that the U.S. has in continuing to be engaged with the ISA even without membership. He emphasized that the first companies to successfully mine the deep seabed will likely dominate the market. Just because the U.S. cannot sponsor contractors does not mean that U.S. companies cannot be involved in deep seabed mining. U.S. companies bring an abundance of expertise to the table, and so there are opportunities for them to be involved.



David Diamond, deputy associate director for energy and minerals at USGS, spoke about the survey's role in conducting seabed ecosystem research and informing international policymakers of scientific advances that could affect rulemaking deliberations.

Diamond provided background on the policy impetus for USGS's actions regarding deep sea minerals. In 2017, an executive order was signed establishing a federal strategy to ensure reliable supplies of minerals considered critical for various reasons. USGS produced a list of 35 minerals it deemed critical, and Diamond noted that close to half of them could be found from marine sources.

On the Outer Continental Shelf (OCS), still within U.S. territory, the Bureau of Ocean Energy Management (BOEM) has jurisdiction over mineral mining activity. It has a two-stage leasing process – prospecting and leasing – and lacks the authority to lease off the shores of U.S. Territories and Possessions. This is important because much of the most valuable areas for marine mineral mining under U.S. jurisdiction, such as Guam and Northern Mariana, are not U.S. states.

USGS has worked with the ISA since 2000, and has worked with it through the Department of State since 2007. It provides science to inform decision-making and participates in workshops defining mineral classifications and discussing environmental considerations.

For the U.S. government, USGS conducts resource evaluation and identification activities to survey areas for marine mineral deposits and collecting and analyzing samples. It also play a role in informing environmental regulations by conducting important basic research.

Diamond noted that currently the majority of interest in deep seabed mining seems to be centered around polymetallic nodules. These small nodules lay on the surface of the sea floor and are of interest because they contain numerous types of minerals. Also, falling under ISA regulation for licensing are ferromanganese crusts and polymetallic sulfides.

Diamond finished his presentation by discussing the environmental considerations of deep seabed mining. He noted that the possibility of deep seabed mining has created both the need and the means for more extensive baseline characterization of the oceans, and deeper insight into ocean processes. There are multiple, different considerations for nodules, sulfides, and crusts, including the removal of substrates and fauna, the creation of plumes, and the release of oxides and substrate particles. USGS is collaborating with academia, industry, and government to better understand these impacts and how to address them. —*Stephen Yaeger, RNRF Program Mgr.*

To access Kerry Kehoe's PowerPoint presentation click [here](#).

To access David Diamond's PowerPoint presentation click [here](#).

Bill Moran Speaks on Open Access at RNRF Round Table



Bill Moran, publisher of the Science family of journals of the American Association for the Advancement of Science (AAAS), hosted the Washington Round Table on Public Policy of the Renewable Natural Resources Foundation (RNRF) on May 6, 2019. He spoke about issues and recent developments related to implementing Open Access to research published in scientific journals.

AAAS CEO Rush Holt and 30 representatives of scientific societies and publishers were present. Holt supplemented Moran's presentation with some observations, and attendees asked numerous probing questions.

Moran began with a description of Open Access, emphasizing that in many cases, the adoption of the OA model is a fundamental change to publishing business models. Adopting an OA policy means that all articles are available openly and at no cost, under a Creative Commons license, allowing for the greatest degree of adaptation and reuse. However, this means that publishers no longer charge subscription fees, instead collecting an Article Processing Charge (APC). These charges are covered by authors, their institution, or research funders, in contrast to publishing costs being covered by subscribers under traditional subscription-based models.

There are three different types of OA models. In Green OA, an author self-archives a version of their paper in a repository, keeping it subject to their own copyright and re-use terms. This type of OA is mandated by most funders and many institutions. Gold OA is when journals make final versions of their article fully accessible with few restrictions. In these cases, APCs are paid upon an article's acceptance to the journal. Journals that use Hybrid OA models offer a Gold OA option, alongside a traditional subscription-based option.

The global policy landscape for Open Access publishing is in a state of flux, largely due to the EU's recent adoption of [Plan S](#), which was created to require that all scientific research that results from public grant funding be published in Open Access journals or platforms. Under this plan, authors will retain copyright, and publishing fees will be paid by funders or universities, not by individual researchers. There will also be a three- to four-year transitional period when Hybrid OA models will be acceptable, after which all journals will be fully OA. However, Hybrid models were not originally allowed, and policies still may be changed. Plan S is supported by 15 national funders (cOAlition S) and five charitable funders.

Moran listed a series of concerns with the Plan S model. Primarily, he said that AAAS is concerned about quality. In an Open Access journal, APCs cause revenues to rise if more articles are published, since the journal is receiving a fee for every article they publish. Therefore, OA journals can easily become more concerned with quantity than quality when evaluating articles for publishing.

Another concern with Plan S is that it uses Gold OA as its standard, when Green OA is a more common policy in the rest of the world. Additionally, it mandates that authors and publishers relinquish control of publication rights, including commercial use and adaptations of their work. It also can stifle international cooperation on science. Overall, Plan S undermines the existing publishing system without having a comprehensive plan on how to replace it.

Plan S currently only applies in EU countries, and The White House Office of Science and Technology Policy (OSTP) has indicated that it has no intention of following suit with an OA mandate. However, some American publishers are exploring OA options for their journals regardless of OSTP pronouncements. This takes place in the form of transformative agreements being executed, new journal launches that are fully OA, flipping existing subscription journals to OA, and adding additional revenue sources through submission fees.

Libraries and consortia have also been taking action: The University of California system recently terminated its subscriptions with Elsevier in support of Open Access for publicly funded research. Additionally, some funders are beginning to publish research themselves. For example, the Bill and Melinda Gates Foundation has created a platform called Gates Open Research which allows Gates-funded researchers to rapidly publish research results. The NIH, in contrast, has a Green OA mandate that requires papers resulting from NIH funding to be made available within 12 months of publication through PubMed Central. Many other funders in the United States have policies very similar to this one, mandating that research be made Open Access on a delayed basis.

Moran also discussed the OA landscape in China. While China has expressed support for Plan S, they have been unclear as to what their own OA policy will be moving forward. Under an OA model in China, total costs would be substantially higher than subscription fees under the current model. Moran also emphasized that China has already passed the US in number of submissions, and as their acceptance rate increases, we will see more research being published out of China.

Overall, the landscape for Open Access publishing is rapidly evolving, both in Europe and in the United States. Moran emphasized the importance of publishers and society members staying up-to-date on Open Access and create new partnerships to collaborate on these issues and communicate thoughts and concerns. —*Stephen Yaeger, RNR Program Mgr.*

To access Bill Moran's PowerPoint presentation click [here](#).

Additional information about Horizon 2020 can be found [here](#) and [here](#).

AAAS's official comments on Plan S can be found [here](#).

American Geophysical Union

AGU Awarded for Thriving Earth Exchange Program



AGU was recognized this June by the American Society of Association Executives (ASAE) with the 2019 Power of A Summit Award for its Thriving Earth Exchange program. The award recognizes organizations whose work positively impacts communities across the U.S. This year, ASAE recognized only six organizations to receive the prestigious award, making it ASAE's highest honor.

AGU's Thriving Earth Exchange initiative seeks to promote collaboration between AGU scientists and communities to support projects that promote sustainability and resilience. Since its launch, the program has impacted the lives of millions of individuals by supporting community initiatives that address global problems such as climate change and pollution. "I am hopeful this award will encourage more scientists to offer their skills to communities and more communities to reach out to scientists," said AGU CEO and Executive Director Chris McEntee. "This award is proof positive that scientific knowledge,

combined with community knowledge, is a powerful way of ameliorating real-world problems in an inclusive and effective manner.”

Thriving Earth Exchange Executive Director Raj Pandya echoed this sentiment, stating that, “This recognition is a testament to the power of cooperation and the value of connecting science and community knowledge, and – most of all – it’s a well-deserved shout out to our scientific volunteers and the community leaders with whom they work.”

Pandya continued on to acknowledge those who played critical roles in supporting the program, stating, “Special thanks to the Thriving Earth Exchange team, our advisory board, AGU leadership, and the AGU Board and Council. We share this award with many collaborators, including Higher Ground, the International City/County Managers Association, National League of Cities, ICLEI USA, iSeeChange, EPA’s Community and Underserved Partnership Program, and Public Lab.”

More about AGU’s Thriving Exchange Program can be obtained [here](#).

Chapman Conference: Winter Limnology in a Changing World

October 14-18, 2019. Polson, MT

<https://connect.agu.org/aguchapmanconference/upcoming-chapmans/winter-limnology>

Recent high-profile syntheses of lake water temperatures and ecology under lake ice are galvanizing a scientific community, and new data streams are being amassed by in situ sensors deployed during seasonal ice cover. We are now positioned to catalyze progress in our understanding of winter limnology inclusive to polar, alpine, and temperate systems. Continued acceleration of winter research by a geographically diverse group of investigators will generate irreplaceable information about lake dynamics and enable future research on lake-climate interactions as we enter an increasingly ice-free world.

To accelerate progress in winter limnology, AGU’s Chapman Conference on winter limnology will address hypotheses associated with 5 topics: climate and ice dynamics; winter and cross-seasonal biogeochemistry; biological connections across seasons; temperature dependency of biotic processes and habitat; and trophic interactions under ice.

Fall Meeting

December 9-13, 2019. San Francisco, CA

<https://meetings.agu.org/fall-meeting-2019/>

AGU’s Fall Meeting will prepare attendees for what’s ahead: rapid developments in our science, new approaches to observing our Earth and beyond, the introduction of new data streams, growing demand for accessible science, the expansion of convergent science, and more.

American Meteorological Society

New Studies Published in Bulletin of the American Meteorological Society Reveal Clear Ties between Today’s Extremes and Human Causes

The U.S. Northern Plains and East Africa droughts of 2017, floods in South America, China and Bangladesh, and heatwaves in China and the Mediterranean were all made more likely by human-caused climate change, according to new research published December 10, 2018, in the *Bulletin of the American Meteorological Society (BAMS)*.

The seventh edition of the report, *Explaining Extreme Events in 2017 from a Climate Perspective*, also included

analyses of ocean heat events, including intense marine heatwaves in the Tasman Sea off of Australia in 2017 and 2018 that were “virtually impossible” without human-caused climate change. Also included are analyses of Australian fires and Uruguay flooding.

This is the second year that scientists have identified extreme weather events that they said could not have happened without warming of the climate through human-induced climate change.

“These attribution studies are telling us that a warming Earth is continuing to send us new and more extreme weather events every year,” said Jeff Rosenfeld, Editor in Chief of *BAMS*. “The message of this science is that our civilization is increasingly out of sync with our changing climate.”

The report presents 17 peer-reviewed analyses of extreme weather across six continents and two oceans during 2017. It features the research of 120 scientists from 10 countries looking at both historical observations and model simulations to determine whether and by how much climate change may have influenced particular extreme events.

BAMS Special Editor Martin Hoerling, a NOAA research meteorologist, said that while the events studied in this issue spanned six continents and a calendar year, what became clear is they are intimately connected.

“These studies confirm predictions of the 1990 First IPCC report, which foresaw that radical departures from 20th century weather and climate would be happening now,” Hoerling said. “Scientific evidence supports increasing confidence that human activity is driving a variety of extreme events now. These are having large economic impacts across the United States and around the world.”

Read the entire press release, along with some findings from the studies, [here](#).

Annual Meeting

January 12-16, 2020. Boston, MA

<https://annual.ametsoc.org/index.cfm/2019/>

The AMS Annual Meeting is the world’s largest yearly gathering for the weather, water, and climate community. It brings together great minds from a diverse set of scientific disciplines– helping attendees make career-long professional contact and life-long friends while learning from the very top people in the atmospheric sciences.

American Society of Civil Engineers

ASCE Announces Launch of Scenario Planning Tool – Future World Vision

This May, ASCE released a report announcing the launch of the ambitious scenario planning project, ‘Future World Vision.’ The program aims to identify potential trends and scenarios that will influence future infrastructure planning by civil engineers.

In formulating the program, ASCE began by identifying six major trends that will influence the work of civil engineers over the next fifty years. The trends identified were:

- Alternative Energy
- Autonomous Vehicles
- Climate Change
- Smart Cities
- High-Tech Construction/Advanced Materials
- Policy and Funding

ASCE then identified four models in which the trends may be further examined over ten, twenty-five, and 50-year increments. The four models used were:

- Resilient Cities
- Progressive Megacities
- Dispersed Settlements
- Unequal Enclaves
- Policy and Funding

By deeply considering the six trends in the context of the four models, ASCE hopes to better prepare its members to work in a changing environment. ASCE Executive Director Tom Smith echoed this sentiment stating, “By looking over the horizon and preparing today for a vastly different world and profession tomorrow, the Future World Vision project will enable ASCE and its members to evaluate future trends and scenarios, and to shape a world that is safe, resilient and sustainable. Ultimately, this project is about achieving the society’s vision of civil engineers serving as global leaders building a better quality of life and preparing for the challenges of tomorrow.”

The full Future World Vision report can be accessed [here](#).

ASCE 2019 Convention

October 10-13, 2019. Miami, FL

<https://www.asceconvention.org/about>

The ASCE Convention is the Society flagship membership event. It is the single annual opportunity that the entire Society is represented together and therefore needs to reflect the diversity that ASCE encompasses. The program for the Convention will be of an integrated, cross-cultural, technical, and educational nature.

American Society of Landscape Architects Fund

Society of Landscape Architects Reaffirms its Commitment to Supporting Climate Change Initiatives

Throughout 2019, the American Society of Landscape Architects (ASLA) has continued to support initiatives that address climate change and equip communities to face the impacts of a changing environment. In April, ASLA signed the “We Are Still In” declaration, a bipartisan affirmation of support for the Paris Agreement. Other signatories included government officials, private sector businesses, and cultural institutions, of which collectively represent 6.2 trillion dollars in revenue. In June, ASLA Executive Vice President and CEO, Nancy Somerville, announced ASLA’s support for S. 1743, the International Climate Accountability Act, which would prohibit President Trump from withdrawing the U.S. from the Paris Agreement. Somerville noted that U.S. participation in the Paris Agreement was essential in limiting damage to the environment and public infrastructure.

ASLA has also recently announced the opening of the Smart Policies for a Changing Climate Exhibition at its Washington D.C. office. The display includes policy solutions and recommendations to make communities more sustainable. These recommendations were created during the ASLA's Blue Ribbon Panel on Climate Change and Resilience which was held last year. The exhibit also features 20 landscape designs from across the U.S. that promote sustainability and resilience.

The exhibition opening follows recent advocacy by ASLA to support legislation that aims to safeguard coastal communities threatened by rising sea levels. In June, ASLA announced its support of S. 3087, the Living Shorelines Act, introduced by Senators Kamala Harris (D-CA) and Chris Murphy (D-CT). The bill would establish a grant system for states to be used in improving coastal infrastructure that is threatened by climate change. Earlier this June, Somerville applauded efforts made by Harris and Murphy, noting that monetary support will be vital in making coastal communities more resilient to a changing environment.

More information about the Smart Policies for a Changing Climate Exhibition can be found [here](#).

Conference on Landscape Architecture

November 15-18, 2019. San Diego, CA

<https://www.asla.org/conference.aspx>

The meeting will feature a diverse spectrum of industry experts speaking on a wide range of subjects, from sustainable design and best practices to new materials and technologies.

More than 130 education sessions and field sessions will be presented during the meeting.

Many of the sessions will also qualify for continuing education credit with the Green Building Certification Institute (toward LEED AP credential maintenance), the American Institute of Architects, the American Institute of Certified Planners, and other allied professional organizations and state registration boards.

American Water Resources Association

AWRA President Reaffirms Support for Integrated Water Resource Management Following Spring Conference

In a statement made this May, AWRA President Lisa Beutler, reaffirmed AWRA's support for Integrated Water Resource Management (IWRM) following criticism from the academic community.

In defending the use of IWRM, Beutler stated, "A lack of communication, mistaken notions, and scattered examples of poor execution have led many to believe that IWRM has expired. They proffer it was just a fad or the management *du jour* of a past decade." Beutler continued, "AWRA has long promoted sustainable water management and the adoption of IWRM principles to achieve it."

Beutler statements follow AWRA's 2019 Spring Specialty Conference with the theme "Setting Conditions for the Success of Integrated Water Resources Management." The conference, held during March 2019 in Omaha, Nebraska, sought to, "support dialogue, sharing, and learning about the tactics, strategies and policies that are helping IWRM succeed across North America and the world." The conference featured abstract presentations highlighting case studies in which IWRM has been successfully used to address water resource issues in Nebraska.

On the first day on the conference, keynote speaker, Tony Willardson, of the Western States Water Council, underscored the importance of IWRM in providing a collaborative framework for solving complex water issues. Willardson emphasized that moving forward, tools that promote interdisciplinary engagement will be crucial in addressing issues of water scarcity.

Beutler echoed this sentiment in concluding her May statement, noting that IWRM principles will be useful in framing collaborative work among stakeholders. Beutler stated, "While technological advances continue to facilitate better understanding interfaces with complex physical systems, the people side of the equation, and the institutions they govern, require more attention."

Beutler's full statement can be read [here](#).

Annual Conference

November 3-7, 2019. Salt Lake City, UT

https://www.awra.org/Members/Events_and_Networking/Events/ANNUAL_WATER_RESOURCES_CONFERENCE.aspx

Praised by attendees year-after-year, AWRA's Annual Conference is an immersive experience, providing attendees with innovative, practical, and applied water resource management solutions, management techniques, and current research. Attendees will hear:

- lessons learned from the implementation of multidisciplinary projects,
- best practices discovered in the design and application of water resource management,
- implications of water policy decisions, and
- research into current and emerging issues.

Geological Society of America

GSA to Host Annual Conference in Phoenix, Arizona

This fall, GSA is set to hold its annual conference in Phoenix, Arizona from September 22-25. The event will host geoscience researchers and professionals in an effort to foster a collaborative environment in which participants will gain valuable knowledge from lectures, field trips, and short courses centering on environmental, economic, energy, and engineering geology.

Special lecturers include GSA's president-elect, Donald Siegel, who will focus on the responsibility of geoscientists to help society adapt to a changing climate. Siegel will also speak to the intellectual challenges associated with dealing with a global issue such as climate change, in addition to highlighting steps to begin an energy transition that is more dependent on renewable resources.

Speaker Scott Tinker, current director of the Bureau of Economic Geology, will also discuss the challenges with beginning an energy transition. Tinker's presentation entitled, "Switch is Back! Energy Poverty, the Energy Transition, and Modern Energy Education" will assess how different energy resources can be used to minimize poverty and environmental degradation.

On the third day of the conference, climate scientist, Katharine Hayhoe will speak to specific environmental and social consequences of climate change and discuss possible actions stakeholders might take to ensure a sustainable future.

On the last day of the conference, Meghan Kish, current superintendent of the Southern Arizona Office of the National Park Service (NPS), will present remarks on how the NPS can begin to foster more interest in STEM fields, particularly in a time when engagement in earth sciences is crucial to maintaining environmental quality and management.

More information about the conference can be learned [here](#).

Society of Environmental Chemistry and Toxicology

SETAC to Hold 14th Europe Special Science Symposium in Brussels, Belgium

In November, SETAC will hold its 14th Europe Special Science Symposium in Brussels, Belgium. Participants will convene on November 19-20 to discuss issues relating to soil biodiversity.

The meeting will also focus on the ecological impacts of various plant protection chemicals used in soils, in addition to discussion on the experimental and modeling techniques used to assess environmental risk.

The symposium will include specialists in ecotoxicology who will provide insight on how soil biodiversity contributes to larger ecosystem function and health. The meeting will provide a forum for discussion and interdisciplinary collaboration among policy makers, scientists, and businesses, with the intention of promoting environmental quality and sustainability.

Key questions that will be addressed during the symposium include:

- What is known about soil biodiversity?
- Why is structural and functional soil biodiversity important?
- Which soil functions depend or are influenced by soil organisms?
- Which methods are available for soil biodiversity?
- How could soil organisms be determined robust, reliably and efficiently?
- Which natural factors affect the occurrence of soil organisms?
- How could the diversity of soil organisms be modeled?
- Which chemical and non-chemical stressors affect soil organism communities?
- Are there case studies available showing the impact of stressors on soil organisms?
- Which regulations exist for the protection of soil organisms?
- Which ideas exist to protect soil organism structural and functional diversity?

More information about the symposium can be learned [here](#).

SETAC North America Annual Meeting

November 3-7, 2019. Toronto, Canada

<https://toronto.setac.org/>

The meeting will emphasize the need for environmental scientists and managers from all sectors (e.g., academia, business, government, non-profit, non-governmental and intergovernmental organizations) to work together at a global scale to address shared environmental challenges. Under such a paradigm, discrete technical advances would be leveraged to create harmonized approaches towards mutual solutions. The meeting offers opportunities to focus on transboundary issues within a holistic system approach.

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