RENEWABLE RESOURCES JOURNAL

VOLUME 35 NUMBER 4

CONTENTS

Special Report:

Endocrine Disrupting Chemicals: An Existential Threat

The Endocrine Society and International Pollutants Elimination Network (IPEN)

Editor's Introduction

This RNRF special report draws heavily from a December 2020 report produced by the Endocrine Society and the International Pollutants Elimination Network titled "Plastics, EDCs, and Health: A guide for public interest organizations and policy-makers on endocrine disrupting chemicals and plastics." This report examines the widespread use of endocrine disrupting chemicals (EDCs) in plastics and the health impacts of exposure to EDCs. Editors have supplemented the report with information about the failure to regulate this toxic range of chemicals and what individuals can do to reduce their exposure to them. EDCs as currently used around the world present an unmanageable existential threat to our environment, health, and future.

It is important to understand that impacts of EDCs can occur at very low levels of exposure and effects can compound across different chemicals, meaning that there is likely no "safe" dosage of an EDC.

Introduction

The rise in prevalence of manufactured chemicals over the past 80 years has occurred alongside increasing alarm over their impacts on public health and the environment. From Rachel Carson's book *Silent Spring* sparking an outrage over the use of DDT pesticides, to more recent concern over chemicals such as BPA and PFAS, the widespread use of chemicals has always been followed by questions about their health and environmental impacts.

One of the most widespread vectors for chemical exposure is through plastics. Plastic products, while incredibly useful for countless applications, expose the population to many potentially harmful chemicals and pose a significant threat to public health. Through the plastic production process, countless chemicals are used, many of which end up in the food we eat, the water we drink, and the air we breathe.

Commonly, EDCs are among the chemicals found in plastics. The Endocrine Society defines an EDC as "an exogenous [non-natural] chemical, or mixture of chemicals, that interferes with any aspect of hormone action."[1] Humans are exposed to these chemicals in a variety of ways, including consumer products, water, and food. They mimic or block the functions of hormones in the body, which can cause a variety of negative health impacts, and especially so when exposure occurs during pregnancy and infancy.

In response to improving understanding of the public health implications of our constant exposure to EDCs, calls to ban or strongly reduce the use of the chemicals have been increasing. Medical societies including the American Medical Association, the Endocrine Society, and the American Public Health Laboratories, among others, have expressed concern over exposure to EDCs used in plastics. Unfortunately, EDCs, like many other types of toxic substances, have proven difficult to regulate. This is partially due to the difficulty of attributing specific health defects to specific chemicals and a high burden of proof for passing regulations.

Overview of the Uses of Endocrine Disrupting Chemicals in Plastics

Most plastics today are composed primarily of substances like polyethylene (PE), polypropylene (PP), and polyvinyl chloride (PVC), which are produced by processing fossil fuel feedstock. Other chemicals are added to this base to achieve certain characteristics and adapt plastics to their countless uses.[2] The affordability of the fossil fuels used to make plastic products and the versatile applications for which plastic can be used have caused an explosion in the pervasiveness of plastic in everyday life.

Additives in plastics are used as fillers, plasticizers, flame retardants, UV stabilizers, biocides, heat stabilizers, antioxidants, lubricants, foaming agents, and catalysts. In addition to chemicals added intentionally to plastics to achieve desired characteristics, others end up in plastic products as unintentional byproducts of the manufacturing process.[3] So many chemicals are used as plastic additives that a complete catalogue of them does not exist, making identification of health impacts and regulation incredibly difficult. 350,000 manufactured chemicals are registered for use around the world, but the identities of over 100,000 of them are either confidential or ambiguously described; according to "Plastics, EDCs, and Health," a conservative estimate is that over 1,000 of these may be EDCs.[4]

Renewable Natural Resources Foundation

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

American Geophysical Union • American Meteorological Society
American Society of Civil Engineers • American Society of Landscape Architects Fund
American Water Resources Association • Geological Society of America
Society of Environmental Toxicology and Chemistry

Renewable Resources Journal

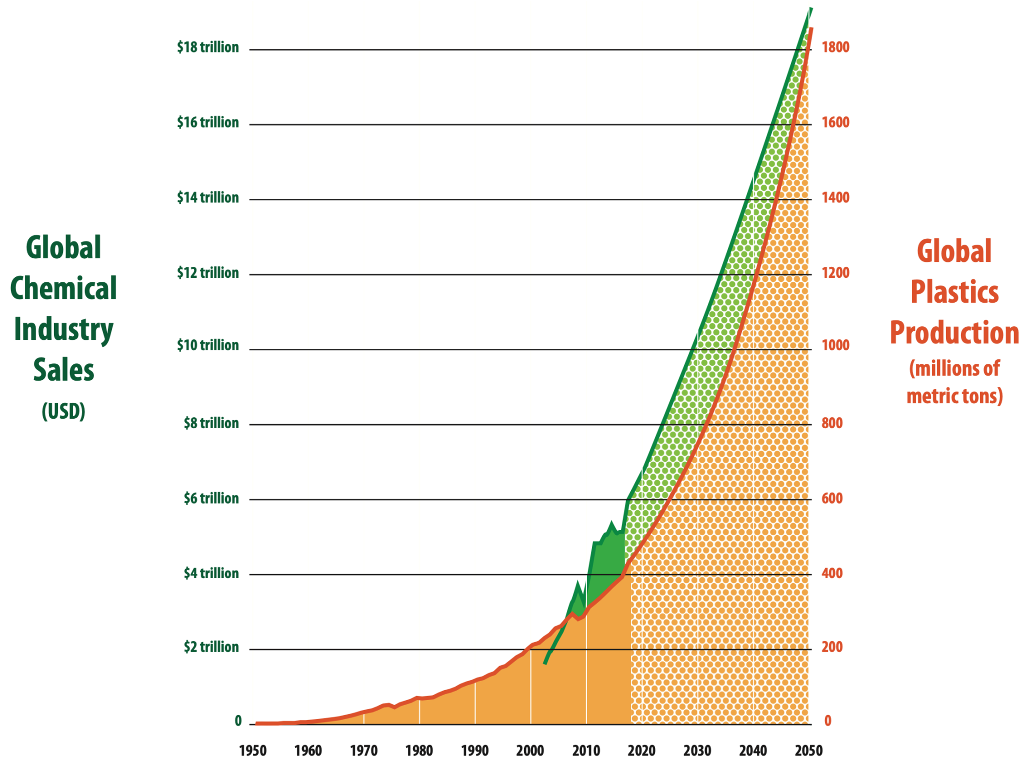
Renewable Resources Journal (ISSN 2578-3998) is published quarterly by the Renewable Natural Resources Foundation, 6010 Executive Boulevard, Suite 700, North Bethesda, MD 20852-3809, USA. Tel: +1 301 770 9101 Email: info@rnrf.org Website: https://www.rnrf.org

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

So many chemicals are used as plastic additives that a complete catalogue of them does not exist, making identification of health impacts and regulation incredibly difficult.

A report from the Nordic Council of Ministers presents a list of 144 chemicals or groups of chemicals used in plastics that are known to be hazardous.[5] Chemicals they identified can be found in common products including shower curtains, rainwear, diapers, plastic toys, car seats, and clothes (including children's clothes).[6] Exposure to the endocrine disrupting chemicals and other toxins in these products can happen at all points in their life cycle: manufacturing, consumer use, recycling, waste management, and in the environment.

EDCs are common in plastic food and beverage packaging and often leech into food products. They can also be found in cooking implements. Even if one makes a conscious effort to avoid the use of plastic products, they may be exposed to harmful EDCs through other pathways. For example, hospitalized patients are frequently exposed to phthalates from IV tubing and blood bags. Environmental exposure can occur through microplastics, which are produced as plastic objects break down with time into tiny particles. Exposure to microplastics often happens through the consumption of fish, especially shellfish. It can also occur through the air we breathe, especially through urban street dust and occupational exposure for people working in fields like waste management.[7]



Chemical industry sales are projected to rise with a complementary rise in plastics production. *Derived from GRID-Arendal, Maphoto/Riccardo Pravettoni*

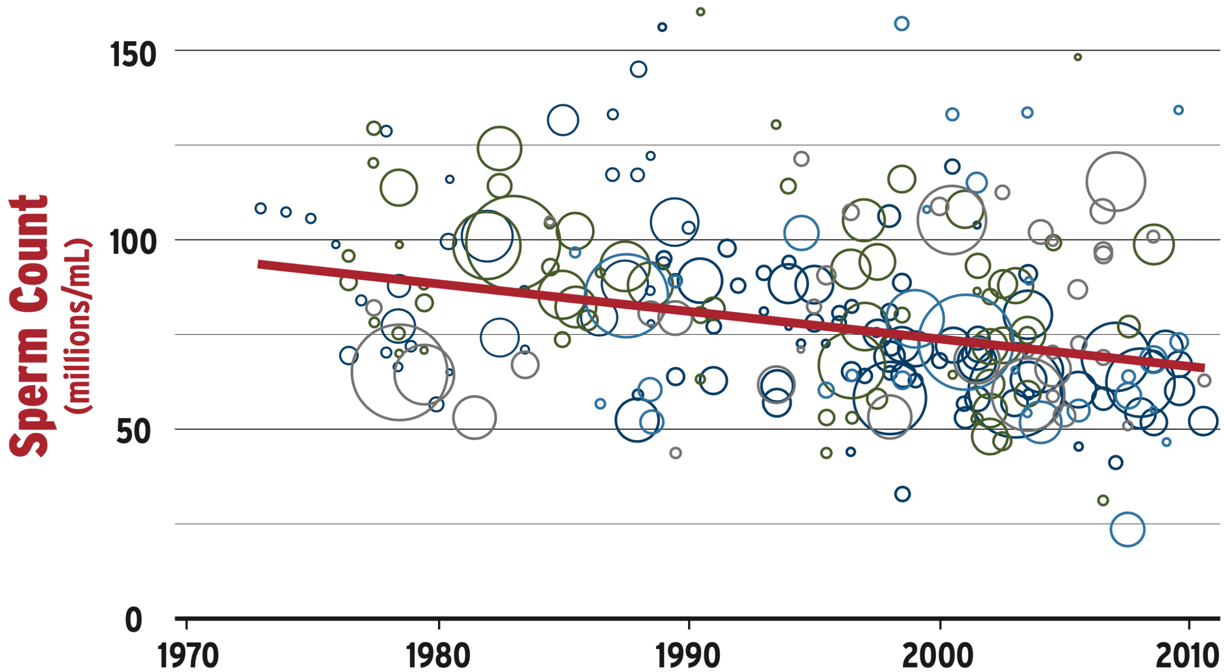
Recently, some plastic production has been replaced by "bioplastics," which use renewable, plant-based raw materials instead of fossil fuel feedstocks to form the base of their chemical structure. While this has the positive environmental effect of reducing demand for fossil fuels, it does not eliminate all of the issues related to plastic production. Bioplastics often contain similar chemical additives to conventional plastics. They also can contribute to other issues like deforestation and increased pesticide use.[8]

Known Health Impacts of EDCs in Plastics

The endocrine system, comprised of a series of glands throughout the body, produces hormones, which travel through the body in the bloodstream and trigger various bodily functions. The system is very complex, and each gland and hormone serves a different function. The endocrine system is essential for human health: it plays a central role in mental and physical development, reproductive function, adaptation to changes in the environment, and metabolic adjustments in response to different nutritional demands.[9]

EDC exposure can modify DNA, causing intergenerational effects such as increased likelihood of neurological and endocrine disorder in one's grandchildren.

Disruptions to the essential processes of the endocrine system can cause serious health issues. This is what makes the EDCs found in plastics so concerning. They can cause drastic health problems, even at small levels of exposure. Plastics have become ubiquitous in human use and in the environment, and human exposure to the chemicals they contain is essentially unavoidable. EDCs work by blocking or mimicking hormone functions, interfering with essential bodily processes.[10]



Evidence for decreasing sperm counts over the past 50 years has been widely reported. Some chemicals used in plastics are known to cause lower sperm counts, and this may play a role in lower fertility rates in many countries. *Source: Levine et al. 2017 [287]*

Unborn fetuses and infants are especially vulnerable to negative health impacts from EDCs. There is evidence that exposure at these stages can affect all of the body's endocrine systems. Early-life exposure can cause health issues that do not emerge until later in life. However, adult exposure can also cause problems.[11] Exposure to individual EDCs does not occur in isolation. Impacts can compound between multiple substances, meaning that low levels of exposure to many different EDCs can still cause issues. Some EDCs are persistent and bioaccumulative, meaning that they remain in human tissue and build up over time.[12]

Exposure to EDCs can have multigenerational effects. This begins with disruptions to reproductive function. EDCs have been shown to directly impact sperm count and quality, as well as chromosomal abnormalities in ova and sperm production. Decreasing sperm counts, in particular, are a very serious issue. A 2017 study found that sperm counts in the west had dropped by 59% between 1973 and 2011.[13] This crisis has increasingly been raising alarm – in a new book, Shanna Swan, an environmental and reproductive epidemiologist who co-authored the 2017 study, warns that falling sperm counts threaten human survival.[14] These effects on reproductive health are associated with issues like subfertility or infertility, which can impact the health of offspring.[15]

If exposed during pregnancy, EDCs can also have effects on one's grandchildren. They can impact the development of germ cells, which are the precursors to sperm and ova. EDC exposure during pregnancy can affect the fetus, as well as the fetus's germ cells which contain the genetic material that will eventually be passed on to the next generation. EDC exposure can modify DNA, causing intergenerational effects such as increased likelihood of neurological and endocrine disorder in one's grandchildren. Since changes to DNA are inherited, defects can also be passed down to later generations: great grandchildren, great-great grandchildren, and beyond.[16]

Disruptions to the endocrine system are fundamental to many of the most prevalent and serious diseases and causes of disability. Due to the importance of endocrine function in the development of many health problems, EDCs may be frequently to blame. According to "Plastics, EDCs, and Health," many endocrine-associated pediatric disorders have become more common in recent decades, including male reproductive problems such as cryptorchidism, hypospadias, and testicular cancer, early female puberty, leukemia, brain cancer, neurobehavioral disorders, and developmental disability. The preterm birth rate has also increased drastically, rising more than 30% since 1981. This is associated with increased risk of neurological disorders, respiratory conditions, and childhood mortality. It can also lead to other issues in adulthood, including obesity, type 2 diabetes, and cardiovascular disease.[17]

The increased incidence of these endocrine system-related health issues has occurred alongside the increased prevalence of plastic and use of additives known to be EDCs. Attribution of specific health defects to specific chemicals is difficult because it generally requires a severe, known exposure to the chemical. Obviously, it would be unethical to intentionally induce such drastic exposures to toxic substances in a laboratory setting. EDC exposure typically happens at low doses, with a mixture of chemicals, and over long time periods. Regardless, evidence does exist linking issues like chronic diseases and cancers in humans to EDCs, often corroborated using animal models. It is important to understand that impacts of EDCs can occur at very low levels of exposure and effects can compound across different chemicals, meaning that there is likely no "safe" dosage of an EDC.[18] The Endocrine Society first took a stance on EDCs in 2009, asserting that there was sufficient evidence to determine that EDCs pose a public health risk. Since then, evidence has only increased that EDCs have health impacts even at very low doses, especially on infants and developing fetuses.[19]

Catalogue of Known EDCs in Plastics

EDCs are used in a plethora of applications in all sorts of plastic products, and humans can therefore be exposed to them through a variety of vectors. Following is a list of EDCs identified by the Endocrine Society and IPEN in their report "Plastics, EDC, and Health," identifying common EDCs found in plastic, potential and proven health impacts, and common exposure pathways. This section is reproduced from the Endocrine Society and IPEN's addendum to their report, titled "7 Harmful Chemicals in Plastics."[20]

Bisphenols

What they are: Bisphenols, such as bisphenol A (BPA), are used as chemical building blocks in polycarbonate plastics and epoxy resins and are used in reusable food and beverage containers, reusable water bottles, the linings of food cans, medical and sports equipment, eyeglass lenses, thermal paper receipts, and plastic water pipes.

Exposure routes: A high production volume chemical, most people are exposed to BPA when it leaches from food contact materials into foods and beverages they consume. BPA leaches from landfills to contaminate wastewater, groundwater, and freshwater, and has been found around the world in beach sand from plastic marine waste. BPA, listed as a substance of very high concern by the European Union, and has been demonstrated to be toxic by hundreds of chemicals studies. Many countries have moved to ban BPA from baby bottles, but there is strong evidence that replacement chemicals exhibit the same health impacts.

Health impacts: A large body of evidence confirms that BPA can affect brain development and behavior. Exposure can increase anxiety, depression, hyperactivity, inattention, behavioral problems, and is also associated with adverse reproductive outcomes affecting cell division in eggs. BPA is associated with Polycystic Ovary Syndrome (PCOS)—a complex hormonal condition associated with irregular menstrual cycles, reduced fertility, and increased risk of diabetes. In men, BPA affects fertility and is associated with sexual dysfunction among men exposed to high occupational levels. BPA is associated with breast, prostate, ovarian, and endometrial cancers.

Alkylphenols

What they are: Commonly used in latex paints, pesticides, industrial cleaners, detergents, personal care products, and many different kinds of plastics as UV stabilizers, alkylphenols are used to spread substances like paints and coatings over surfaces.

Exposure routes: Alkylphenols are used in numerous applications that contribute to human exposures, including cleaners and degreasers, adhesives, emulsifiers, cosmetics, and personal care products, paints, and dust control agents. Some alkylphenols are approved for use as indirect food contact substances, and others are used as heat stabilizers for PVC in water pipes and flooring.

Health Impacts: These chemicals mimic estrogen and disrupt reproductive systems. Alkylphenols are linked to male infertility, low sperm count, and disrupted prostate development. Studies have shown occupational exposure is associated with heightened risk of male and female breast cancers.

Phthalates

What they are: Phthalates are chemical additives widely used to produce or promote flexibility and to reduce brittleness in plastics. Phthalates are used as plasticizers in PVC consumer, medical, and building products, as matrices and solvents in personal care products, and as fillers in medications and dietary supplements, food and beverage packaging, and children's toys. The phthalate DEHP is common in medical devices such as plastic tubing. Some phthalates are restricted in the European Union and are classified as substances of very high concern.

Exposure Routes: Daily human exposures via oral ingestion, inhalation, and skin contact are common. Phthalates frequently leach from items such as food packaging, cosmetics, body care products, and toys into the environment and into products that humans use and consume. The most common routes of exposure are via oral ingestion from food packaging and the use of cosmetic products, but high levels of phthalates are also present in household dust. They are metabolized quickly and are present in 90-100% of amniotic fluid samples from second-trimester fetuses, cord blood samples from newborns, breast milk from nursing mothers, and even in human ovarian follicular fluid.

Health Impacts: Phthalates reduce testosterone and estrogen levels, block thyroid hormone action, and have been identified as reproductive toxicants. Decreased pregnancy and high miscarriage rates, anemia, toxemia, pre-eclampsia, early menopause, and abnormal sex steroid hormone levels are associated with phthalates. Phthalate exposures are not only associated with reduced fertility but can affect fertility across multiple generations. Developmental exposure to phthalates affects gene expression, and perinatal phthalate exposure affects asocial behaviors. Phthalate exposure increases the risk of insulin resistance and has been persistently linked to diabetes. Phthalates are associated with elevated blood pressure, obesity, and elevated levels of triglycerides.

Perfluorinated Compounds

What they are: Perfluorinated chemicals are widely used in water and stain-resistant clothing, food contact wrappers, lubricants, carpet treatments, paints, cookware, and as a dispersant in firefighting foams, as well as other industrial and consumer applications. PFAS and PFOA are listed under the Stockholm Convention on Persistent Organic Pollutants, and PFHxS, used as a substitute, has been recommended for listing by the convention's technical experts. Perfluorinated chemicals are used to make fluoropolymers for plastics.

Exposure routes: PFAS chemicals contaminate local water sources. The use of PFAS chemicals in industry and firefighting foam used in airports and military bases are sources of pervasive drinking water and groundwater contamination throughout the world. Most people are exposed to PFAS from drinking tap water. PFAS also leaches into local water systems from PFAS containing waste in landfills. In addition, PFAS leaches from wrappers and cookware into our food.

Health Impacts: PFAS are metabolism disrupting chemicals affecting the immune systems, liver, and thyroid function. They alter puberty, raise breast cancer risk, and are associated with kidney, testicular, prostate, and ovarian cancers, and non-Hodgkin's lymphoma.

Brominated Flame Retardants

What they are: Brominated flame retardants (BFRs) are a class of chemicals used to reduce flammability in plastic products and prevent the spread of fires. They are used in foams, polystyrenes, and epoxy resins that are used to manufacture electronic casings and wire coatings (examples include the plastic casings for computers, TVs, and home appliances), textiles, furniture foams, carpets, building materials, and are commonly found in plastic children's toys.

Exposure Routes: BFRs leach from products and are present in household dust. Small children ingest BFRs from hand to mouth behavior, and from mouthing toys made from recycled plastics that contain BFRs. Processing of plastic waste is a significant source of human BFR exposure because although BFRs are controlled, the Stockholm Convention allows some BFRs in plastic materials for recycling. Global sampling has demonstrated that the widespread presence of BFRs in plastic children's toys made from recycled plastics are available in stores throughout the world.

Health Impacts: BFRs disrupt male and female reproductive development, alter thyroid development, and affect neurodevelopment. BFR exposure is associated with psycho-motor and attention-related IQ performance in children.

Dioxin

What they are: Dioxins, considered the world's most toxic substances, are byproducts of industrial and combustion processes and occur in the production of plastic products with BFRs and when plastics with BFRs are incinerated or heated in a recycling process to be re-molded into new products. There is no safe level of dioxin exposure. They are fat soluble, bind to soils, and can accumulate in animal and human fatty tissues.

Exposure Routes: Dioxin exposures can occur through oral, dermal and inhalation routes. Children mouthing toys made of recycled plastic that derives from e-waste are at risk of dangerous health effects from the toxic material. Dioxin contamination of local food chains has been documented in communities where e-waste shipments are dumped and incinerated, landfills where plastic waste accumulates, and where plastic waste is incinerated for fuel at levels that are comparable to dioxin hotspots.

Health Impacts: Dioxin exposures affect brain development, disrupt thyroid and immune system functions, and are associated with increased risk of multiple cancers, and immune system damage.

UV Stabilizers

What they are: UV stabilizers are chemical additives used to protect plastic building materials, automotive parts, waxes, and paints from deterioration due to UV radiation. Several UV stabilizers are on the Candidate List of Substances of Very High Concern by the European Chemicals Agency (ECHA) because of their persistent, bio-accumulative, and toxic nature. The Swiss government has recently submitted a proposal to the Stockholm Convention to list UV-328 as a Persistent Organic Pollutant under provisions of the Stockholm Convention.

Exposure Routes: UV stabilizers can leach from food packaging materials into our food. The chemicals also have been found in house dust.

Health Impacts: Several studies demonstrate that UV stabilizers disrupt endocrine function, impeding normal development and inducing estrogenic effects.

Failure to Regulate EDCs

Despite the clear and growing evidence that EDCs present a threat to human and environmental health, they continue to be used widely. This is a part of a larger trend, especially in the U.S., of toxic substances being chronically underregulated. Regulation of toxic substances falls under the jurisdiction of multiple federal agencies and laws. For instance, the Toxic Substances Control Act (TSCA) and Safe Drinking Water Act (SDWA) give jurisdiction to the Environmental Protection Agency (EPA); the Consumer Product Safety Improvement Act (CPSIA) and Federal Hazardous Substances Act (FHSA) give jurisdiction to the Consumer Product Safety Commission (CPSC); and the Federal Food, Drug, and Cosmetic Act (FDCA) and Food Quality Protection Act (FQPA) give jurisdiction to the Food and Drug Administration (FDA).[21] Despite these laws aimed at protecting people from exposure to toxic substances, the U.S.'s regulatory framework has remained a patchwork of policies insufficient to provide comprehensive public health protections.

The Government Accountability Office consistently includes the regulation of toxic substances as a "high risk" operation in the American government, including in January 2021, when it said that the government's approach to the issue had actually worsened in the past two years.[22] It is usually difficult to prove with high confidence that a specific chemical caused a specific health defect in a person. This contributes to the difficulty of regulating toxic substances, since regulation usually requires a high burden of proof. The most direct evidence of the toxic effects of chemicals usually comes from large-scale events where acute exposure leads to obvious health issues.[23]

Under TSCA, the EPA has always had to meet a very high standard to be able to regulate a toxic substance. When the act was passed in 1976, 62,000 industrial chemicals which were already in use were grandfathered into commercial authorization and assumed to be safe unless the EPA could prove that they posed "unreasonable risk" to human health and/or the environment, a difficult standard to meet. For newly introduced chemicals, minimal health and safety information provided by industry made it nearly impossible for the EPA to properly evaluate substances in the short timeframe they were given under the law.[24] While the Lautenberg Act, signed into law in 2016, included much-needed reforms to TSCA, the EPA's approaches to implementation thus far have undercut its efficacy.[25]

One of the provisions of the Lautenberg Act required the EPA to identify chemicals for risk evaluation and potential regulation. Some EDCs are among the substances being evaluated, including multiple types of phthalates and flame retardants. However, no chemicals have been prohibited yet under the revised law, and testing for endocrine disruption is not specifically mentioned in the act.[27]

TSCA cannot be used to regulate toxic substances in certain types of products, including food, food additives, and cosmetics.[28] Regulation of substances in those applications is under the authority of the FDA. Plastic products that come into contact with food are regulated as indirect food additives. These include packaging and containers as well as anything else in the supply chain that comes into contact with food. However, many EDCs remain unregulated by the FDA in these applications.

The FDA has banned BPA in certain applications like baby bottles, sippy cups, and baby formula packaging, but only after those uses were already phased out. Other uses in food contact materials are still allowed.[29] In 2016, a group of NGOs filed petitions for the FDA to take action on phthalates in food. The agency still has yet to do so, despite the fact that industry has acknowledged the use of three phthalates in food packaging which have been deemed dangerous enough to be banned in children's toys.[30] The FDA has banned certain types of long-chain PFAS in food contact materials after they were found to have dangerous health effects and were largely phased out in food contact uses. However, other types of PFAS are still authorized for use in applications including nonstick cookware and food packaging.[31]

Under the FHSA, CPSC has the authority to require labelling of products containing dangerous chemicals and can ban chemicals that are so dangerous that labelling is deemed insufficient to protect consumers. This applies only to products which are likely to be brought to places where people live.[32] In 2008, the Consumer Product Safety Improvement Act was passed. The act banned three types of phthalates in children's products, passed an interim ban on three others, and directed the CPSC to study and evaluate the addition of other types of phthalates to the ban (leading to the permanent ban of five types of phthalates from children's products in 2017).[33] The CPSC began to consider a ban on certain types of flame retardants in consumer products in 2017, but they have yet to put one into place.[34] The CPSC does not currently regulate bisphenols or PFAS despite these chemicals' existence in consumer products.

Often, when chemicals are found to be dangerous to human health, they are phased out by industry. Sometimes this is due to regulatory action, but other times it is in response to public concern over chemicals. However, chemicals that are phased out are often replaced by others that have similar properties and may pose similar risks, but are less well-studied. For example, the perfluorinated compounds PFOS and PFOA were phased out by industry, only to be replaced with other, similar chemicals. Recent studies have begun to uncover the dangers of these replacements. One asserted that short-chain PFAS replacements are “more widely detected, more persistent and mobile in aquatic systems, and thus may pose more risks on the human and ecosystem health” than their predecessors.[35] Similar concerns have been voiced about bisphenols: as BPA has become less widely used due to health concerns, it has frequently been replaced in the same applications with BPF and BPS, other bisphenols with similar chemical properties.[36] Concerns have also been voiced about about replacements to phased-out flame retardants.[37]

The health impacts of each individual EDC do not occur in a vacuum – exposure to multiple different types of EDC can cause compounding effects. This means that, even if exposure to each individual chemical is low enough that it would not be considered dangerous on its own, the sum effects of multiple chemicals can still cause health problems. Current toxic substance regulations fail to reflect this reality.[38]

Even if comprehensive regulations are implemented as soon as possible, health problems from exposure to EDCs will not end anytime soon. Durable plastic products like building materials and certain consumer goods will continue to exist and be used. Products made from recycled plastic can hold phased-out chemical additives if they are not properly processed or sorted.[39] Exposure from toxins that have built up in the environment will also continue since the vast majority of plastic ever produced has ended up in landfills, waterways, the ocean, and other environments.[40]

What Can Be Done to Limit Exposure to EDCs in Plastic

The New York State Children’s Environmental Health Centers have produced a guide for reducing exposure to EDCs.[41] The following are steps that they identify that one can take to minimize exposure:

- Store and heat food and beverages in glass containers.
- Reduce household dust with a wet mop or dusting rag.
- Do not heat plastic containers in the microwave or dishwasher.
- When possible, choose fresh foods over processed or canned foods.
- Opt for low-fat dairy products and low-fat or lean meat products such as fish, seafood, and poultry.
- Choose safer cleaning products: avoid products that contain antibacterial chemicals, scents or fragrances, or harsh chemicals. and look for those with a “Safer Choice” label. Or, create your own out of common affordable ingredients: white vinegar, baking soda, water, and lemon or orange.
- Check the labels of personal care products to ensure that they do not contain phthalates, parabens, triclosan, or fragrances. If they do not clearly display what they contain, try to avoid those with strong scents.
- Repair, cover, or replace pieces of furniture that have torn or exposed foam.
- Choose electronic receipts (“e-receipts”) instead of paper ones.
- Choose safer plastics. Plastics with recycling label 1, 2, 4, and 5 tend to be safer than those with labels 3, 6, and 7, which can contain phthalates, BPA, and other EDCs.
- According to “Plastics, EDCs, and Health,” eating organic foods can reduce exposure to pesticides that can be EDCs, and eating fresh foods can reduce exposure to EDCs often found in processed and canned foods.[42]

References

1. Zoeller RT, Brown TR, Doan LL, Gore AC, Skakkebaek NE, Soto AM, Woodruff TJ, Vom Saal FS. Endocrine-Disrupting Chemicals and Public Health Protection: A Statement of Principles from The Endocrine Society. *Endocrinology*. 2012;153:4097-4110.

2. Jodi Flaws, Pauliina Damdimopoulou, Heather Patisaul, Andrea Gore, Lori Raetzman, Laura Vandenberg. “Plastics, EDCs, and Health: A guide for public interest organizations and policy-makers on endocrine disrupting chemicals & plastics.” The Endocrine Society and International Pollutants Elimination Network (2020): 33, https://www.endocrine.org/-/media/endocrine/files/topics/edc_guide_2020_v1_6chqennew-version.pdf.

3. Flaws et al. “Plastics, EDCs, and Health.” 39.

4. Flaws et al. “Plastics, EDCs, and Health.” 18.

5. Stenmarck Å, Belleza EL, Fråne A, Busch N, Larsen Å, Wahlström M. “Hazardous substances in plastics - ways to increase recycling.” Nordic Council of Ministers (2017).

6. Flaws et al. “Plastics, EDCs, and Health.” 40.

7. Flaws et al. “Plastics, EDCs, and Health.” 41-42.

8. Flaws et al. “Plastics, EDCs, and Health.” 36.

9. Flaws et al. “Plastics, EDCs, and Health.” 15.

10. Flaws et al. “Plastics, EDCs, and Health.” 19.

11. Flaws et al. “Plastics, EDCs, and Health.” 22.

12. Flaws et al. “Plastics, EDCs, and Health.” 24.

13. Hagai Levine, Niels Jørgensen, Anderson Martino-Andrade, Jaime Mendiola, Dan Weksler-Derri, Irina Mindlis, Rachel Pinotti, Shanna H Swan, Temporal trends in sperm count: a systematic review and meta-regression analysis, *Human Reproduction Update*, Volume 23, Issue 6, November-December 2017, Pages 646–659, https://doi.org/10.1093/humupd/dmx022.

14. Miranda Bryant, “Falling sperm counts ‘threaten human survival,’ expert warns.” *The Guardian,* February 26, 2021. https://www.theguardian.com/us-news/2021/feb/26/falling-sperm-counts-human-survival.

15. Flaws et al. “Plastics, EDCs, and Health.” 25.

16. Flaws et al. “Plastics, EDCs, and Health.” 25-26.

17. Flaws et al. “Plastics, EDCs, and Health.” 27-28.

18. Flaws et al. “Plastics, EDCs, and Health.” 30-31.

19. Flaws et al. “Plastics, EDCs, and Health.” 9-10.

20. “7 Harmful Chemical Types in Plastics.” The Endocrine Society and IPEN. (2020). https://www.endocrine.org/-/media/endocrine/files/topics/2020-dec-7-harmful-chemicals-backgrounder.pdf.

21. Shibley C., Farquhar D., Ransom M., Caucci L. “Using Law and Policy to Address Chemical Exposures: Examining federal and state approaches.” *Capital University Law Review* 2014;42(1):97–141. https://www.cdc.gov/phlp/docs/chemical-pp.pdf.

22. “GAO High Risk Series.” U.S. Government Accountability Office. 2021. https://www.gao.gov/highrisk/transforming-epas-process-assessing-and-controlling-toxic-chemicals.

23. Flaws et al. “Plastics, EDCs, and Health.” 21.

24. Sheldon Krimsky, “The unsteady state and inertia of chemical regulation under the US Toxic Substances Control Act.” *PLoS Biol* 15(12) (2017). https://doi.org/10.1371/journal.pbio.2002404.

25. Kevin McLean, “Three Years After – Where Does Implementation of the Lautenberg Act Stand?” Harvard University Environmental and Energy Law Program. February 26, 2020. https://eelp.law.harvard.edu/2020/02/three-years-after-where-does-implementation-of-the-lautenberg-act-stand/.

26. “Chemicals Undergoing Risk Evaluation under TSCA.” U.S. Environmental Protection Agency. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/chemicals-undergoing-risk-evaluation-under-tsca.

27. Christopher D Kassotis, Laura N Vandenberg, Barbara A Demeneix, Miquel Porta, Remy Slama, Leonardo Trasande. “Endocrine-disrupting chemicals: economic, regulatory, and policy implications.” *Lancet Diabetes Endocrinology* (2020) 8: 719–30. https://doi.org/10.1016/S2213-8587(20)30128-5.

28. “Toxic Substances Control Act (TSCA) and Federal Facilities.” U.S. Environmental Protection Agency. https://www.epa.gov/enforcement/toxic-substances-control-act-tsca-and-federal-facilities.

29. “Questions and Answers on Bisphenol A (BPA) Use in Food Contact Applications.” U.S. Food & Drug Administration. https://www.fda.gov/food/food-additives-petitions/questions-answers-bisphenol-bpa-use-food-contact-applications.

30. Tom Neltner. “How and when will FDA rule on ortho-phthalates in food? It’s anyone’s guess.” Environmental Defense Fund. January 29, 2019. http://blogs.edf.org/health/2019/01/29/fda-ortho-phthalates-food-anyones-guess/.

31. "Authorized Uses of PFAS in Food Contact Applications." U.S. Food & Drug Administration. https://www.fda.gov/food/chemicals/authorized-uses-pfas-food-contact-applications.

32. "Federal Hazardous Substances Act (FHSA) Requirements." U.S. Consumer Product Safety Commission. https://www.cpsc.gov/Business--Manufacturing/Business-Education/Business-Guidance/FHSA-Requirements.

33. "Consumer Agency to Ban Harmful Chemicals in Children's Toys." Natural Resources Defense Council. October 18, 2017. https://www.nrdc.org/media/2017/171018-0.

34. "Flame Retardants." U.S. Consumer Product Safety Commission. https://www.cpsc.gov/Business--Manufacturing/Business-Education/Business-Guidance/flame-retardants.

35. Alex Formuzis. "Study: Newer PFAS Chemicals 'May Pose More Risks' Than Those They Replaced." Environmental Working Group. https://www.ewg.org/release/study-newer-pfas-chemicals-may-pose-more-risks-those-they-replaced.

36. Flaws et al. "Plastics, EDCs, and Health." 43.

37. Susan Shaw, Jennifer Harris, Michelle Berger, Bikram Subedi, Kurunthachalam Kannan. "Brominated Flame Retardants and Their Replacements in Food Packaging and Household Products: Uses, Human Exposure, and Health Effects." In *Toxicants in Food Packaging and Household Plastics,* ed. Suzanne Snedeker (London: Springer, 2014), 61-93.

38. Flaws et al. "Plastics, EDCs, and Health." 23-24.

39. Flaws et al. "Plastics, EDCs, and Health." 40.

40. Flaws et al. "Plastics, EDCs, and Health." 35.

41. "Plastics and Hormone Disrupting Chemicals." New York State Children's Environmental Health Centers. https://nyscheck.org/plastic/.

42. Flaws et al. "Plastics, EDCs, and Health." 23.

Special Report:

The Improbable Viability of Carbon Capture and Storage

Tyndall Centre for Climate Change Research

Introduction

Carbon capture and storage (CCS) refers to processes that remove carbon dioxide (CO_2) from the atmosphere and sequester it, often underground in geological formations. This set of technologies is often included as an important part of climate change mitigation plans and hypothetical emissions reduction pathways. However, the technology's consistently underwhelming performance has caused many to doubt whether it is wise to rely on such an unproven innovation. Although CCS technology has existed in theory for decades, its deployment has been consistently slower than expected, raising questions about its viability as a major contributor to the global mitigation of climate change.

Especially prior to 2030, it is very unlikely that CCS will reach a high enough level of deployment to contribute significantly to the reduction of atmospheric carbon. This is an important timeline because many countries' emissions reduction plans under the Paris Agreement dictate their strategies up to 2030, and some include CCS despite the fact that it is unlikely to be deployed at scale by that point, if ever. Additionally, emissions reductions in the 2020s are essential to remaining under 1.5° C of warming, a key goal of the Paris Agreement. This RNRF special report summarizes and builds upon the ideas presented in "A Review of the Role of Fossil Fuel-Based Carbon Capture and Storage in the Energy System," a 2020 report produced by the Tyndall Centre for Climate Change Research and commissioned by Friends of the Earth Scotland, and Global Witness. It describes the prominence of CCS in carbon mitigation plans, historical and prospective limitations on its effective deployment, and the improbability that it will become a viable, large-scale contributor to achieving carbon neutrality on a global scale.

The Rising Profile of CCS

Recently, as climate change has become a matter of greater concern to the public, the topic of CCS has received increased attention. It receives frequent news coverage, which often portrays it optimistically as a likely contributor to climate change mitigation in the coming years. It has especially been a focus of efforts by fossil fuel companies to portray themselves as more sustainable. For instance, in early 2021 Exxon Mobil pledged to spend $3 billion on "low-emission technologies" (mostly CCS projects) through 2025, an amount that represents less than 5% of the company's capital budget over that time frame. Much of that budget will be spent on projects that already existed, and the company has taken the position that tax credits will be necessary to make CCS commercially viable.[1] Alongside this investment in CCS, the company has plans to drastically increase its oil production, and therefore its carbon emissions, causing many to question the sincerity of its sustainability commitment.[2]

Because even small- to moderate-sized earthquakes threaten the seal integrity of CO2 repositories, in this context, large-scale CCS is a risky, and likely unsuccessful strategy for significantly reducing greenhouse gas emissions.

CCS also figures into long-term government planning for reducing global emissions under the Paris Agreement. The agreement asks countries to put forth two types of plans for emissions reductions. Nationally Determined Contributions (NDCs) are shorter-term plans for reducing emissions, usually extending about a decade into the future. The other category of plan, Long-term Low Emissions and Development Strategies (LEDS), usually extend to 2050 and beyond. While some countries include CCS as part of their NDCs, they are a much more common inclusion in LEDS, and factor into most countries' long-term decarbonization plans. As of March 2021, 25 of the 29 long-term strategies that had been submitted include CCS as part of their path to decarbonization.[3] As of November 2020, 11 countries had CCS as a part of their NDC.[4] This smaller count of countries set on implementing CCS on a shorter timescale is reflective of the current state of the technology and the fact that it has habitually underperformed projections for large-scale deployment.

In its LEDS, submitted in November of 2016, the United States proposes a variety of scenarios that would lead to "deep decarbonization" with a goal of reducing carbon emissions by 80% before 2050 compared to 2005 levels.[5] The plan lists CCS as one of its methods for achieving this decarbonization. It especially focuses on capturing carbon from bioenergy generation methods (known as BECCS, or bioenergy with carbon capture and storage), touting this technology as potentially carbon-negative. However, it acknowledges that the technical and economic feasibility of CCS has yet to be fully demonstrated. In line with this, the plan also provides for emissions reduction scenarios that do not rely on CCS.[6] More recently, President Joe Biden has expressed interest in supporting CCS on a wide scale, stating in his campaign that "he will double down on federal investments and support tax incentives" for the use of carbon capture technologies.[7] It remains to be seen whether this will factor into the U.S.'s new NDC, which is expected to be announced in April of 2021. In March of 2021, a new bill was introduced by a bipartisan group of members of congress which would fund the development of CCS infrastructure, signaling support for these technologies in the legislative branch as well.[8]

In its 2018 special report "Global Warming of 1.5° C," the Intergovernmental Panel on Climate Change (IPCC) describes various scenarios that would allow the warming of the climate to remain below 1.5° C above pre-industrial levels. To varying degrees, many of these scenarios include widespread deployment of CCS as a necessary contributor to emissions reductions. The IPCC proposes that CCS can be used to reduce emissions from coal and natural gas combustion, as well as bioenergy production. They also describe scenarios that do not require CCS, but instead drastically and immediately reduce energy demand and conduct large-scale afforestation.[9] Although CCS is included in the IPCC's scenarios, the report's authors acknowledge the significant uncertainty around relying on these technologies to achieve the 1.5° goal: "There is uncertainty in the future deployment of CCS given the limited pace of current deployment, the evolution of CCS technology that would be associated with deployment, and the current lack of incentives for large-scale implementation of CCS…. No proposed technology is close to deployment at scale, and regulatory frameworks are not established."[10]

History and Background on CCS

CCS was first demonstrated for expressly environmental goals in 1996. However, the technology predates its environmentalist applications. It was first introduced in the 1970s for a process called Enhanced Oil Recovery (EOR), by which captured carbon is injected into oil wells to force more oil out. This results in the sequestration of CO_2 in the geological formations that originally held the oil. Still today, the vast majority of CCS capacity is used for EOR: 22 of the 28 CCS plants around the world are used for EOR, accounting for 81% of CCS capacity.[11]

There is disagreement about what the role of EOR should be among climate solutions. It can reduce the average amount of carbon emissions that result from fossil fuel extraction, but also leads to the extraction of more fossil fuels, which is the root cause of the climate crisis. EOR dominates the CCS sector because it is, in the absence of significant carbon pricing or other regulatory measures, one of very few applications of CCS that can be profitable.[12] As a consequence of tying the economic viability of CCS to the profitability of oil, these facilities can be subject to shutdowns due to fluctuations in oil prices. This has happened to Petra Nova Carbon Capture, the second coal plant to open with CCS integration, which began operating in 2017 in Texas. It used captured carbon from its coal-burning power plant to conduct EOR, successfully operating until 2020 when it closed due to the low price of oil.[13] Petra Nova is one of very few EOR facilities that utilizes captured carbon from fossil fuel combustion – most existing plants use CO_2 from naturally occurring geological deposits, meaning that they are not removing CO_2 from the air and have no benefit for reducing atmospheric carbon. This is because captured CO_2 is not available at most oil fields, necessitating large infrastructure investments to make its use accessible.[14]

CCS growth has been slow in the past decade. Between 2010 and 2020, global capacity rose only from 10 million metric tons (Mt) of CO_2 per year to 39 Mt/year. This growth has been significantly slower than expected. In 2010, 150 Mt/year of capacity was in development, but only a small fraction of that has become operational.[15] There are many explanations for this underperformance. Uncertainty about the economic feasibility of the technology is often an issue. Additionally, ownership structures often expect developers to be responsible for the "full chain" of the CCS process, including the long-term commitment to monitor storage sites and prevent leaks. This is often a deterrent to capital investment in CCS. Significant movement away from coal as an energy source has also played a role, since many proposed CCS projects were attached to coal-fired power plants.[16]

Requirements to take ownership over the "full chain" of processes, as well as the long-term commitment of monitoring, measurement and verification are barriers to development. This can explain why more modular technologies like solar, wind, and energy storage have seen much quicker deployment.

Another factor that has limited deployment of CCS is the energy penalty associated with adding CCS to the generation process. Capturing and sequestering carbon requires the use of energy, so it reduces the output of power plants and makes them less profitable. Depending on the method of CCS used, energy penalty can vary significantly. For post-combustion capture technology, which is beneficial because it can be used to retrofit existing combustion power plants with CCS, energy penalty can reach as much as 28%. Alternatively, facilities which use pre-combustion capture technology can have energy penalties as low as 5%. Pre-combustion capture requires the use of chemical processes to remove CO_2 from fuel before combustion, leaving a hydrogen-rich fuel and pure CO_2. However, capital costs are higher for this type of plant.[17]

Challenges to Future Deployment of CCS

CCS faces a number of challenges that will likely hamper its ability to meet the expectations being set out for it in climate goals. In addition to its historical underperformance, there are prospective challenges that will make it difficult to implement the technology on a sufficient scale for it to meaningfully contribute to climate change solutions, especially over the next decade.

A concern with CCS in the long term is the potential that stored CO_2 will leak back into the atmosphere, preventing carbon from being permanently sequestered. A 2012 study in *Proceedings of the National Academy of Sciences* argued that "there is a high probability that earthquakes will be triggered by injection of large volumes of CO_2 into the brittle rocks commonly found in continental interiors. Because even small- to moderate-sized earthquakes threaten the seal integrity of CO_2 repositories, in this context, large-scale CCS is a risky, and likely unsuccessful, strategy for significantly reducing greenhouse gas emissions."[18] Others have more optimistic perspectives. The Tyndall Center report summarized research that suggests that if proper precautions are taken, including choosing stable sites, regulating the amount of pressure used when sequestering to avoid triggering earthquakes, and carefully monitoring the site in the long-term, the practice can be conducted safely and effectively.[19]

A 2018 study examined likely levels of carbon leakage from CCS sites over the course of the 21st century and repercussions of that leakage in warming scenarios and policy responses. The study found that carbon leakage could lead to the escape of about 3% of captured carbon back into the atmosphere. The authors propose responding to such likelihood of leakage by accounting for it in the carbon budget and pricing it accordingly. If the cost of leaked carbon is properly accounted for, it will raise the cost of CCS implementation, and therefore reduce deployment an estimated 30% for fossil fuel CCS and 10% for BECCS. This is preferable to the alternative of not pricing or accounting for likely carbon leakage, which would instead lead to an increase in global temperature rise 0.01-0.02 degrees higher than it would be otherwise due to carbon leaking back into the atmosphere with time.[20]

If the safe, large-scale, long-term sequestration of CO_2 can be accomplished, it will require a robust regulatory framework to ensure that proper practices are being used. Central to these efforts will be Monitoring, Measurement and Verification (MMV) of sites to ensure on an ongoing basis that carbon is remaining safely sequestered in the earth. Some countries, like the UK, have already begin developing regulatory frameworks for CCS, although experts say that a global regulatory framework will be necessary for CCS to reach its full potential.[21] The stability of these frameworks will be very important if CCS is to be successful, since the effective MMV of storage sites will be necessary indefinitely to keep carbon from returning to the atmosphere.

Another significant challenge to the future of CCS is the financing of non-EOR operations. The reason that 81% of existing CCS capacity is used for EOR is that it is, at the moment, the most profitable use for captured carbon. Even so, the volatility of oil prices can cause these facilities to shut down, as was seen at Petra Nova in Texas. The scale and complexity of CCS facilities is also a barrier to investment. CCS receives comparisons to nuclear energy due to the comprehensive set of facilities needed to successfully implement it – capture facilities are necessary alongside transportation, storage, and MMV. Requirements to take ownership over the “full chain” of processes, as well as the long-term commitment of MMV, are barriers to development. This can explain why more modular technologies like solar, wind, and energy storage have seen much quicker deployment. If implementation of CCS occurs on a large scale, it will likely be due to significant government intervention to de-risk the process and incentivize investment, especially for non-EOR applications.[22]

Conclusion

In order to achieve the goals of the Paris Agreement, global emissions must be drastically reduced as quickly as possible. If this does not happen, the 1.5° C warming target will likely be out of reach by 2030.[23] To date, CCS deployment for decarbonizing the power, heat, and transportation sectors has been largely nonexistent, has consistently underperformed expectations, incompletely removes carbon from emissions streams, and is very unlikely to be implemented on a meaningful scale by 2030.[24] In the short term, CCS will not be viable enough to contribute to climate solutions, and should not be relied upon. It has better prospects in the long term, but even then, concerns about leakage and the costs of implementation raise questions. Until these concerns are more thoroughly addressed, countries should rely on more proven technologies to reach their decarbonization goals.

References

1. Kevin Crowley, “Exxon’s New Carbon Capture Plan Looks a Lot Like Its Old One,” *Bloomberg Green,* February 1, 2021, https://www.bloomberg.com/news/articles/2021-02-01/exxon-makes-3-billion-carbon-capture-vow-after-climate-pressure.
2. Benjamin Storrow, “Exxon’s Internal Plans Reveal Rising CO_2 Emissions,” *Scientific American,* October 7, 2020, https://www.scientificamerican.com/article/exxons-internal-plans-reveal-rising-co2-emissions/.
3. Intergovernmental Panel on Climate Change, “Communication of long-term strategies,” accessed April 6, 2020, https://unfccc.int/process/the-paris-agreement/long-term-strategies.
4. Brad Page, Guloren Turan, and Alex Zapantis, “Global Status of CCS 2020,” *Global CCS Institute,* November 2020, 26, https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Global-Status-of-CCS-Report-English.pdf.
5. The White House, “United States Mid-Century Strategy for Deep Decarbonization,” November 2016, 6, https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf.
6. The White House, “United States Mid-Century Strategy,” 2016, 7.
7. Joe Biden 2020 campaign platform, “The Biden Plan for a Clean Energy Revolution and Environmental Justice,” 2020, https://joebiden.com/climate-plan/.

8. Office of Senator Chris Coons, "Bipartisan group introduces nation's first comprehensive CO2 infrastructure bill," March 17, 2021, https://www.coons.senate.gov/news/press-releases/bipartisan-group-introduces-nations-first-comprehensive-co2-infrastructure-bill?et_rid=49317284&et_cid=3709853.

9. Samira Garcia Freites and Christopher Jones, "A Review of the Role of Fossil Fuel-Based Carbon Capture and Storage in the Energy System," Tyndall Manchester Climate Change Research, December 2020, 5, https://foe.scot/wp-content/uploads/2021/01/CCS_REPORT_FINAL.pdf.

10. Joeri Rogelj, Drew Shindell, Kejun Jiang, et al., "Mitigation Pathways Compatible with 1.5° C in the Context of Sustainable Development," *IPCC Special Report on Global Warming of 1.5° C* (2018): 158, https://www.ipcc.ch/sr15/.

11. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 12.

12. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 13.

13. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 15.

14. Christophe McGlade, "Can CO2-EOR really provide carbon-negative oil?" *International Energy Agency,* April 11, 2019, https://www.iea.org/commentaries/can-co2-eor-really-provide-carbon-negative-oil.

15. Page, Turan, and Zapantis, "Global Status of CCS 2020."

16. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 12.

17. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 17.

18. Mark Zoback and Steven Gorelick, "Earthquake triggering and large-scale geologic storage of carbon dioxide," *Proceedings of the National Academy of Sciences* vol. 109 no. 26, June 26, 2012, https://doi.org/10.1073/pnas.1202473109.

19. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 23.

20. Adriano Vinca, Johannes Emmerling, and Massimo Tavoni, "Bearing the Cost of Stored Carbon Leakage," *Frontiers in Energy Research* vol. 6, May 15, 2018, https://doi.org/10.3389/fenrg.2018.00040.

21. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 24.

22. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 24.

23. UN Environment Program, "Emissions Gap Report 2020," December 9, 2020, https://www.unep.org/emissions-gap-report-2020.

24. Freitas and Jones, "A Review of Fossil Fuel-Based Carbon Capture and Storage," 26.

Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators

Travis A. Grout, Phoebe A. Koenig, Julia K. Kapuvari & Scott H. McArt

Executive Summary

Insecticides are effective tools for controlling pests and therefore provide aesthetic, economic, agricultural, or conservation benefits to farmers, land managers, and other stakeholders. For some insect pests, chemical insecticides are currently the only practical, economical means of control. At the same time, insecticides can harm non-target organisms. This includes pollinators, some of which are currently experiencing range contractions and population declines. The scientific consensus is that, along with loss of habitat, climate change, parasites/disease, and inadequate management practices, insecticides and other pesticides are contributing to pollinator declines.

Since neonicotinoid insecticides first became commercially available in the early 1990s, they have become the most widely used class of insecticides in the world. Neonicotinoids are used as foliar sprays, soil drenches, trunk injections, and applied as seed coatings before planting. As with any pest management product or practice, the use of neonicotinoids has both benefits and risks. They are highly effective at controlling many types of insect pests and exhibit relatively low toxicity to humans, including pesticide applicators. All neonicotinoids are systemic, meaning they absorb into plant tissues and spread throughout the plant, providing continuous protection for a length of time. On the other hand, neonicotinoids can persist in the environment, accumulate in pollen and nectar, and are highly toxic to many non-target organisms, including insect pollinators.

In August 2018, with funding provided through the Environmental Protection Fund to research potential adverse impacts of pesticides, such as neonicotinoids, Cornell began developing a risk-benefit analysis of neonicotinoid insecticide usage in New York State with the following three goals: 1) Estimate the pest control and plant protection benefits of neonicotinoid insecticides under current usage in New York, 2) Estimate the risk from neonicotinoids to pollinators, and 3) Evaluate the relative benefits and risks of likely neonicotinoid substitutes (i.e., other insecticides or pest control strategies) compared to neonicotinoids. This report summarizes the research undertaken to address those goals.

As the scope of this report is limited to direct economic benefits to users and risk to pollinators, it is intended to complement existing studies and risk assessments, particularly the comprehensive reviews of neonicotinoid active ingredients conducted by the U.S. Environmental Protection Agency (USEPA) and New York State Department of Environmental Conservation (NYSDEC). At the same time, this risk assessment is unique in that it summarizes new analyses and quantifies benefits to users and risk to pollinators in a side-by-side manner for five major application contexts: field crops (corn, soybean, wheat), fruit crops (e.g., apple, strawberry, blueberry), vegetable crops (e.g., squash, pumpkin); ornamentals, turf, & landscape management (e.g., golf courses, ornamental plant nurseries), and conservation & forestry.

While this risk assessment is intended to support evidence-based decisions, we make no recommendations or policy prescriptions. Instead, this document aims to clarify the trade-offs between benefits to users and risk to pollinators that may be inherent to policy decisions or regulatory actions regarding neonicotinoid insecticides.

Value of neonicotinoids in New York State

Neonicotinoid products used outdoors[1] in New York contain the active ingredients acetamiprid,

[1] Though not addressed in this report, neonicotinoids are also used in some veterinary (e.g., flea treatments) and household (e.g., control of bed bugs) applications.

clothianidin, dinotefuran, imidacloprid, or thiamethoxam. These active ingredients are available in many formulations and labelled for use against numerous agricultural and landscape/ornamental pests, including aphids, adelgids, leafhoppers, flies, whiteflies, borers, leaf-feeding beetles, and white grubs. Neonicotinoids are also widely used for managing invasive forest pests such as hemlock woolly adelgid, emerald ash borer, and Asian longhorned beetle.

While alternative insecticides or pest control strategies exist for nearly all relevant target pests, switching from neonicotinoids usually entails a direct or indirect cost to users. Farmers and pesticide applicators choose products with care. When they use a neonicotinoid insecticide, it is typically because that product is the best option when considering price, efficacy, safety, insecticide rotation pattern, and other factors. The value of a neonicotinoid to users is the expected increase in benefits from using the neonicotinoid product instead of the best available non-neonicotinoid pest control product or technique. Many neonicotinoid-based products have important advantages that are difficult to quantify with existing data (e.g., safety for pesticide applicators, or the "insurance value" of preventive products that protect against unpredictable pests).

To assess the direct economic value of neonicotinoid insecticides for users, this report draws on data from over 5,000 paired field trials that compare the performance of a neonicotinoid-based insecticide to that of a chemical or non-chemical alternative. For many applications, the data show that neonicotinoids consistently increase net income, reduce crop damage, or provide superior pest control compared to likely substitutes. For other applications, the benefit to New York users is small or ambiguous.

For many New York fruit and vegetable crops, soil- and foliar-applied neonicotinoid products provide consistent benefits for farmers and are important components of insecticide rotations. For a handful of important pests, such as root-form phylloxera (grape), root weevils (berries), boxwood leafminer (ornamentals), and thrips and Swede midge (cabbage), there are few or no effective chemical alternatives available in New York. In cases where there are effective alternatives, they may be more expensive, require greater safety protection for applicators, or need to be applied more frequently. Even if there are effective, affordable substitutes for neonicotinoid products, farmers benefit from access to insecticides with diverse modes of action. The removal of any one insecticide from a rotation increases the risk of developing insecticide-resistant pest populations and increasing long-term pest management costs to farmers. In some foliar applications, products based on the neonicotinoid acetamiprid, which has relatively low toxicity to beneficial insects including pollinators, can be an effective alternative to those based on the nitroguanidine neonicotinoids imidacloprid and thiamethoxam.

In contrast to neonicotinoid applications in fruit and vegetable crops, routine use of neonicotinoid-treated seeds does not consistently increase net income for New York field corn or soybean producers. Treated seeds are commonly used as a preventative measure rather than in response to site-specific risk from pests. While seed treatments benefit farmers when there is high early-season pest pressure, these benefits are limited to a small proportion of fields. Specifically, 87-93% of field trials find no increase (or a decrease) in corn yield compared to chemical alternatives or untreated controls when neonicotinoid-treated seeds are used in corn fields within the state, region, or North America. Even when compared to plots using no insecticides, 89% of field trials observe no increase in corn yield when neonicotinoid-treated seeds are used. Similarly, 82-89% of field trials find no increase (or a decrease) in soybean yield compared to chemical alternatives or untreated controls when neonicotinoid-treated seeds are used in soybean fields within the state, region, or North America. Nevertheless, neonicotinoid-treated seeds are used by nearly all conventional field corn farmers and, likely, the majority of soybean producers in New York. In part, this is due to the insurance value of neonicotinoid-treated seeds. Even if routine use of neonicotinoid-treated seeds does not increase expected net income, such preventative pest control products protect growers against unpredictable, potentially severe, losses from early-season pests. Incentives and policies to reduce usage of neonicotinoid-treated seeds may benefit from recognizing their value as inexpensive crop insurance as well as a pest management tool.

Risk of neonicotinoids to pollinators in New York State

Neonicotinoid insecticides potentially pose a risk to pollinators due to their high toxicity, systemic activity in plants (i.e., they spread throughout the entire plant, contaminating pollen and nectar, which are food sources for pollinators), and relatively lengthy persistence in the environment. A recent worldwide meta-analysis of in-hive pesticide residue studies found that, under current use patterns, five insecticides pose substantial risk to bees: thiamethoxam, phosmet, chlorpyrifos, imidacloprid, and clothianidin. Three of those five insecticides are neonicotinoids (thiamethoxam, imidacloprid, and clothianidin).[2] However, this study and others suggest that risk to pollinators from neonicotinoid insecticides varies greatly with the conditions of their use. Thus, to assess when and where neonicotinoids pose substantial risk to bees, we conducted a systematic review of over 400 peer-reviewed studies, performed a quantitative risk assessment based on the literature review, and conducted new research with honey bees and bumble bees in New York to assess exposure and risk in multiple settings.

The analysis shows that neonicotinoids can, but do not always, result in risk to bees in New York and elsewhere. The most comprehensive data come from field crops settings, particularly in and near corn and soybean fields. Data from ninety-six exposure assessments indicate that 74% of neonicotinoid exposures are likely to impact honey bee physiology, 58% of exposures are likely to impact honey bee behavior, and 37% of exposures are likely to impact honey bee reproduction. Exposures were often found at over 100 times the concentration known to impact pollinators. Furthermore, exposures in field crops settings occurred months and even years after neonicotinoids were used, indicating widespread contamination in and near corn and soybean fields. Particularly concerning is the ubiquity soils containing neonicotinoids at levels known to be toxic to pollinators. These contaminated soils pose a threat to ground-nesting bees, which comprise 54% of New York's 417 species of bees.

In addition to risk in field crops settings, the data indicate that neonicotinoids used on cucurbits and turf containing weedy flowers result in exposures that are likely to impact honey bee reproduction in 85% and 100% of cases, respectively. The USEPA has recently recognized the high risk of neonicotinoids in cucurbits, issuing a recommendation to prohibit use of imidacloprid-, clothianidin-, and thiamethoxam-based products on cucurbits between vining and harvest to protect pollinators. Our analysis extends this window before the vining stage, since applications before or during planting (i.e., treatments applied to soils before seeding or at the time of transplanting) result in exposures known to impact honey bee reproduction. In turfgrass settings, a simple and effective risk mitigation strategy exists: mowing turf before spray applications of imidacloprid is known to reduce concentrations in weedy flowers by 98%. In addition, use of the anthranilic diamide chlorantraniliprole as a substitute for imidacloprid results in much less risk to bees while providing similar control against important turfgrass pests.

Less comprehensive pollinator exposure data exists for other application contexts, limiting what can be inferred regarding risk from neonicotinoids in these contexts. This surprising knowledge gap is an important finding of this report. Specifically, aside from cucurbits, only four exposure assessments for pollinators (all from sunflower) have been conducted for other vegetable crops. Similarly, only eighteen exposure assessments have been conducted for ornamental plants, and only twenty-four exposure assessments exist for fruit crops. From these assessments, the data indicate that risk to bees can be high; 89% of neonicotinoid exposures in ornamentals are likely to impact honey bee physiology, 83% of exposures are likely to impact honey bee behavior, and 61% of exposures are likely to impact honey bee reproduction.[3]

The data from fruit crops also indicate that risk to bees can be high, but is lower than other application contexts; 50% of neonicotinoid exposures in fruit crops are likely to impact honey bee physiology, 38% of exposures are likely to impact honey bee behavior, and 17% of exposures are likely to impact honey bee reproduction. Additional studies focusing on neonicotinoid exposures to pollinators in vegetable crops, fruit crops, and

---

[2] Phosmet and chlorpyrifos are organophosphate insecticides.

[3] These summary values are only for ornamentals.

ornamentals contexts would be helpful for understanding whether the limited data to date are representative of overall patterns.

Finally, it is important to emphasize that neonicotinoid usage does not always result in risk to pollinators, nor are neonicotinoids the only pesticides contributing to risk. For example, our own data from New York apple orchards and strawberry plantings during bloom shows that applications of acetamiprid result in the greatest insecticide exposures to bees in these crops. However, this neonicotinoid poses low risk to bees due to its low toxicity compared to the two nitroguanidine neonicotinoids (imidacloprid and thiamethoxam) and other non-neonicotinoid insecticides (e.g., chlorpyrifos and indoxacarb) that are currently used in New York fruit crops. In addition, risk to pollinators is likely negligible following trunk injections for invasive forest pests such as hemlock woolly adelgid, emerald ash borer, and Asian longhorned beetle, simply because pollinators are not likely to be exposed to neonicotinoids in those contexts. Thus, specific neonicotinoid active ingredient and application context are key considerations when evaluating risk from neonicotinoids and other pesticides to pollinators.

Relative benefits and risk of neonicotinoids compared to likely substitutes in New York State

Neonicotinoid insecticide applications in New York State have real benefits for insecticide users and real risks for insect pollinators. However, those benefits and risks vary greatly among common application contexts.

For some application contexts, the quantifiable benefits of neonicotinoids are minor or confined to a small number of users. Notably, neonicotinoid-treated corn and soybean seeds do not consistently increase expected net income compared to untreated seeds or pyrethroid insecticide alternatives.[4] At the same time, widespread use of neonicotinoid-treated seeds incurs risks for insect pollinators. In studies of neonicotinoid exposures in field crops, 37-74% of known exposures are predicted to have adverse impacts on honey bee behavior, physiology, or reproduction. Because pyrethroids are not systemic in plants and are less environmentally persistent, these alternatives likely pose less risk to pollinators compared to neonicotinoid-treated seeds. In addition, the anthranilic diamides chlorantraniliprole and cyantraniliprole show promise as alternative systemic insecticide seed treatments for corn and soybean, respectively, though they are currently more expensive than neonicotinoids. Finally, a main reason why preventative seed treatments are used so extensively in field crops is due to the unpredictable nature of early-season pest outbreaks. Further work to improve the predictability of such outbreaks via degree-day modeling that includes site-specific characteristics, or to control early-season pests with non-synthetic chemical insecticides (e.g., biocontrols, biopesticides or RNA-based approaches), will increase the sustainability and security of field crops production in New York.

In other application contexts, a shift away from neonicotinoids will likely place a greater burden on farmers and pesticide applicators. As noted above, there are few or no effective chemical alternatives to neonicotinoids for several important agricultural pests (e.g., root-form phylloxera, root weevils, boxwood leafminer, Swede midge). Even when effective substitutes are available, the loss of neonicotinoids from insecticide rotations would be problematic for some New York crops. Long-term control of the Colorado potato beetle and other important pests may be difficult without access to insecticides with several different modes of action, including neonicotinoids. If treated repeatedly with a single class of insecticide, pest populations can develop resistance more rapidly. That said, chemical insecticides are not the only means of controlling the vast majority of agricultural and non-agricultural insect pests in New York. Integrated Pest Management (IPM) that includes pest monitoring, non-synthetic chemical insecticides, and new technologies that are rapidly emerging in the digital and precision agriculture fields, provide multiple tools for farmers and pesticide applicators to control insect pests. Again, greater development and adoption of these non-synthetic chemical pest control options will increase the sustainability and security of New York agriculture, while also reducing risk to non-target organisms in non-agricultural contexts such as turf/ornamentals and conservation/forestry.

For a few application contexts, restrictions on neonicotinoids could have negative environmental consequences.

---

[4] There is stronger evidence of net income benefits for neonicotinoid-treated seeds in vegetable crops, and field crops growers do benefit from the insurance value of neonicotinoid-treated seeds.

Most importantly, New York relies on neonicotinoid-based products to contain and control hemlock woolly adelgid. There are currently no effective, affordable alternatives for slowing progress of this pest, which kills almost 100% of infested trees. Hemlocks are the third most common tree in New York, and are an ecologically important foundation species, so ending control of hemlock woolly adelgid with neonicotinoids could have severe consequences for New York forests. Because pollinators are not known to interact extensively with wind-pollinated hemlocks, risk to pollinators is likely negligible following trunk injections with neonicotinoids in this context.

Overall, this report aims to summarize current knowledge regarding the direct economic benefits of neonicotinoid insecticides to users and risk to pollinators in New York. The report does not assess other environmental risks or indirect economic impacts associated with usage of neonicotinoid insecticides. We suggest a key contribution of the report is showing that benefits and risks of neonicotinoids vary based on numerous factors such as neonicotinoid type, crop or pest system, application method and timing, and landscape context. Furthermore, it is essential to consider risk from neonicotinoids in relation to their likely substitutes. No pest management product or technique is risk-free, and several likely alternatives to neonicotinoid products pose risks of their own. To this end, we make note of contexts in which IPM approaches, non-synthetic chemical insecticides, and other pest control technologies are likely to be effective. A key recognition of this report is the need for continual, science-based, adaptive approaches to IPM through investment in research and extension of that research to farmers and other pesticide applicators in New York. With new technologies rapidly emerging in digital and precision agriculture, along with more biologically-based solutions, there is an ongoing need for pest control tools that are effective while also being environmentally sustainable. Farmers and other pesticide applicators will adopt environmentally sustainable solutions when such solutions are easy to use, relatively inexpensive, safe and effective.

As outlined above and throughout the report, while this risk assessment is intended to support evidence-based decisions, we make no recommendations or policy prescriptions. Finding the "best policy" or "best policies" for neonicotinoid insecticides in New York will require thoughtful choices between competing priorities.

*This article was excerpted from the Cornell University publication "Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators." Copyright © 2020 Cornell University. To view the full report, click **here**.*

News and Announcements

Renewable Natural Resources Foundation

Now Accepting Nominations for RNRF's 2021 Awards Program

RNRF is now accepting nominations for its 2021 Awards Program.

The **Sustained Achievement Award** recognizes a long-term contribution and commitment to the protection and conservation of natural resources by an individual.

The **Outstanding Achievement Award** recognizes a project, publication, piece of legislation, or similar concrete accomplishment that occurred during the three years prior to nomination for the award.

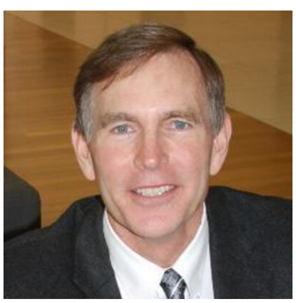
The **Excellence in Journalism Award** honors and encourages excellence in print journalism about natural resources, recognizes work by an individual, group, or organization for both print and digital media.

Nominations will be accepted until June 1, 2021.

For more information on selection criteria, eligibility, and submission instructions, visit the **Call for 2021 Awards Nominations.**

For more information on RNRF's Awards Program and lists of past winners, visit RNRF's **Awards Program page.**

RNRF Round Table Report: The Challenges of Allocating Colorado River Water – Hot 20-year drought and soaring populations



Brad Udall, a Senior Water and Climate Research Scientist at Colorado State University, spoke at a virtual meeting of the RNRF Washington Round Table on Public Policy on March 9, 2021. He discussed the imbalance between water supply and demand in the Colorado River basin, how climate change is exacerbating the issue, and the ongoing renegotiation of the river's management guidelines.

Introduction and Background

The Colorado River basin extends into seven states (Wyoming, Colorado, Utah, Arizona, New Mexico, Nevada, and California) as well as Mexico, along with the land of 29 Native American tribes. The American portion of the basin represents 8% of the area of the lower 48 states. Altogether, about 40 million people, including the populations of all major cities in the Southwestern U.S., rely on the Colorado for some portion of their water supply. The river is used heavily for municipalities as well as agriculture, with about 4.5 million acres of irrigated land in the basin.

The water supply in the river is often measured by the water levels in its two major reservoirs, Lake Mead and Lake Powell. These are the two biggest reservoirs in the U.S. In order to maintain sustainable levels in these two reservoirs over a long time period, withdrawals from the river must equal the supply being provided by the river's flow. This was the case in 2000, when the combined contents of the reservoirs were over 90% full. Since then, their water level has dwindled to less than 50% due to a "structural deficit" – demand for the river's water consistently outpacing supply. This is due in large part to the fact that over the past 20 years, the basin has been experiencing its worst drought on record. The flow of the river has decreased from ~14.75 million acre-feet (maf) to ~12.4 maf. Even before the drought began, water demand was high in the basin; since about 1990, it has not reliably reached the ocean.

While the current situation in the watershed is usually described as a drought, a lack of precipitation is really only half the story. Regional temperature increases, exacerbated by climate change, have also had a significant impact on the reduction of water availability. Udall noted that evaporative losses will only become more severe as climate change worsens. The Southwest is already one of the quickest-warming areas of the country, a trend that is expected to continue. The risk of multidecadal droughts will also continue to drastically increase in coming decades. The 2000-2018 period was the second-driest 19-year period in the basin since 800 AD. While this is partially attributed to natural variation, researchers have said that 50% of the decrease in soil moisture can be attributed to anthropogenic climate change. Climate change has turned what would likely be a moderate drought into an extreme, historic drying event. Aridification and heating, along with reduction in precipitation, are causing drastically drying conditions in a river basin that tens of millions of people rely on for their water.

Historical Management of the River

In 1922, to fully allocate use of the river's water, the basin states agreed to the Colorado River Compact. This agreement still serves as the basis for the Law of the River, which is the set of rules for the river's allocation and management. In response to the "hot drought" happening since 2000, new modifications to the Law of the River have been necessary to prevent the reservoirs from becoming depleted. The first of these, called the Colorado River Interim Guidelines, went into effect in 2007. These guidelines set out a series of complicated rules for how Lakes Powell and Mead are operated, allowing different quantities of water to be released from them when they are at certain elevations. They constrain use of water when the reservoirs are low. One innovative structure used to accomplish this is "intentionally created surplus," which allows parties in the lower basin to store their water in a sort of "bank account" in Lake Mead.

Around 2013, it was becoming clear that persistently dry and hot conditions were rendering the 2007 Interim Guidelines insufficient. A new agreement was necessary. As a result, two new "Drought Contingency Plans" (DCPs) for the Upper and Lower Basins were adopted in 2019. Early in 2021, for the first time, drought conditions in the river reached the point where the DCPs' provisions were activated. Udall noted that these agreements made some progress toward making the river's use more sustainable but were not a permanent solution.

Future Management of the River

Udall finished his presentation by discussing future prospects for sustainably managing the river in these drying conditions. In 2026, the 2007 Interim Guidelines and DCPs expire. The seven basin states, 29 tribes, Mexico, and the federal government have already begun the multi-year process of renegotiating a new set of guidelines which will be adopted in 2027. The following are some central considerations for a successful new agreement described by Udall.

The Upper Basin's "Delivery" Obligation

Among the problems that stakeholders are aiming to resolve is the nature of the Upper Basin's delivery obligations. There is a clause in the original Colorado River Compact that says that the Upper Basin shall not allow the flow of the river to decline below 75 maf every ten running years. However, it is not clear if this obligation is really a "delivery" obligation or if it is a "non-depletion" obligation. If it is a delivery obligation, that means that the entire reduction of flow coming from the Upper Basin due to climate change falls on the Upper Basin to solve. Clearly, this was not the intent of this clause in the original 1922 compact, and the Upper Basin states are making this argument.

Tribal Issues

Native American tribes are expected to have a much more significant role in the renegotiation of the Interim Guidelines than they have had in previous decision-making processes for management of the river. There are 29 tribes in the basin. Altogether, they have a right to control about 20% of the basin's water. This right derives from a 1908 Supreme Court decision which issued the "Winters Doctrine." This doctrine said that when the federal government creates a reservation of land for a tribe, implicit in that reservation is a water right.

However, tribal interests were still left out of the 1922 compact, and many of their rights remain unquantified. Even in the 21st century, the tribes in the basin were not invited to participate in the 2007 Interim Guidelines negotiations or the 2012 Basin Study. The 2019 DCPs were an important development in the inclusion of tribes in river management discussions after their needs and rights had been historically ignored. For the first time, these 29 distinct tribes were acting collectively and were included in the planning process. The DCPs were also the first time that a tribe agreed to accept a monetary payment in exchange for using less than their full water right. Inclusion of tribal interests in the renegotiation of the Interim Guidelines is expected, and will be essential to the new agreement's success.

The Structural Deficit

Fundamental to the dilemma faced by basin stakeholders in this renegotiation process is the "structural deficit." This is, quite simply, an imbalance between the supply of and demand for water in the basin. Since 2000, demand has outpaced supply. Demand reductions are challenging because once a water user has access to a supply of water, it is difficult to get them to relinquish it. The supply-side is more challenging to address. In the absence of cooler temperatures and more precipitation – conditions increasingly unlikely as climate changes — it is difficult to create more supply. It is easier to change consumption patterns than it is to change the hydrology of the river. Without demand reductions in the Upper and Lower Basins, there is a high probability that the amount of water in the reservoirs will continue to fall.

Udall referenced a recent study that found that the Upper Basin's water demand is unsustainably high. Despite this finding, parts of the Upper Basin actually want to increase their demand, which in the face of declining flows is an issue that will need to be addressed in the negotiation process. Demand Management measures, by which water users can voluntarily accept money in exchange for reducing their water consumption, will likely be part of the solution in the Upper Basin but caps on demand may also be necessary to ensure that the delivery obligation is fulfilled.

In the Lower Basin, the Central Arizona Project diverts water from the Colorado River into Arizona, providing water for an area including the cities of Phoenix and Tucson. As a part of the original agreement that permitted this project, it was agreed that if there ever was a shortage of water in the basin, Arizona would bear the brunt of demand reductions. Demand reductions will likely be necessary in the Lower Basin but Udall noted that it would be difficult in practice to mandate that they all come from Arizona. Solving this dilemma will be a part of the new Interim Guidelines negotiations. One method that may be used is to begin charging evaporative losses to state water budgets in proportion to their use. Currently, evaporation is being charged to nobody, which is a part of the overuse problem.

Guidelines for Successful Renegotiation

Udall also identified other steps that can be taken by stakeholders to work toward a successful new set of interim guidelines. First, he emphasized the importance of good science. Realistic climate and hydrological modelling are necessary to inform the negotiations. Udall noted that many of the models being used by watershed states are overly optimistic with regard to future hydrology. Beginning the negotiations with inaccurate presumptions about the future of the watershed are setting the new agreement up for failure. While the renegotiation is a political process, it needs to be informed by most accurate scientific information possible.

Because the structural deficit is a basin-wide issue, Udall advocated for the use of a combined metric that adds the quantity of water in Lakes Mead and Powell. This would be a more accurate way to gauge water shortages because the water in the reservoirs individually is less important than the total quantity between them when informing the management of the entire river basin. He also said that using clear language in negotiations is critical. For instance, one should never inaccurately say that the Colorado River Compact itself is being renegotiated. It is only the Interim Guidelines that are being replaced; the Compact remains the foundation for the river's allocation.

The renegotiation process is more than just a group of stakeholders sitting around a table, working out a plan for the river. It is a series of large and small meetings, some more formal than others. Since not everything is negotiated in official sessions, there is room for behind-the-scenes discussion while also maintaining transparency. During the round table's Q&A session, Udall mentioned that river management issues under discussion will be reported by many talented journalists, who will bring transparency to the process for interested parties.

Ultimately, the process of renegotiating the Interim Guidelines requires a balancing of political, economic, environmental, and societal values. Climate change is the defining issue of our time, and it is at the center of these water issues in the American West. While one can easily become disillusioned by political processes, especially in the realm of climate and environmental issues, Udall ended on a note of optimism. While the solutions are not all clear, there are good relationships among stakeholders, which will form a solid foundation for successful negotiations.

– Stephen Yaeger, RNRF Program Manager

In his presentation, Udall referenced a series of studies about the climate and hydrological conditions of the Colorado River. They can be found at the following links:

Increasing influence of air temperature on upper Colorado River streamflow

The twenty-first century Colorado River hot drought and implications for the future

On the Causes of Declining Colorado River Streamflows

Unprecedented 21st century drought risk in the American Southwest and Central Plains

Large contribution from anthropogenic warming to an emerging North American megadrought

Colorado River flow dwindles as warming-driven loss of reflective snow energizes evaporation

When is Drought not a Drought? Drought, Aridification, and the "New Normal"

Alternative Management Paradigms for the Future of the Colorado and Green Rivers

American Geophysical Union

AGU Fall Meeting 2021

December 13-17, 2021

New Orleans, LA and online

At this time, AGU is planning the 2021 Fall Meeting as a "hybrid" meeting, aimed to optimize both in-person and worldwide virtual participation and to present a best-in-class experience for all attendees. Join us for Fall Meeting 2021 in New Orleans, Louisiana.

For more information, visit AGU's website **here**.

American Meteorological Society

AMS Signs Multi-Organization Letter of Support for the Scientific Integrity Act

On March 23, 2021, the American Meteorological Society signed on to a multi-organization letter of support for the Scientific Integrity Act. This act would ensure that scientists can carry out their research – and communicate it to the public – without fear of political pressure or retaliation. As the federal government continues to respond to the COVID-19 pandemic and work toward recovery, it is essential that science and expert opinion are unconstrained by political interference, fear of retribution or suppression.

To read the full letter, click **here**.

American Society of Civil Engineers

2021 World Environmental & Water Resources Congress

June 7-11, 2021

Planning a Resilient Future Along America's Freshwaters

Now being held virtually, attendees taking part in the EWRI Congress will have the opportunity to share their research on issues affecting the environment and the policies relating to water resources. As a water community, we will focus on using our existing knowledge, combined with fresh ideas to maximize resources and develop best practices as we strive for a healthy future environment.

For more information, click **here**.

American Society of Landscape Architects Fund

ASLA Teams Up with EarthDay.org for the Great Global Cleanup 2021 during World Landscape Architecture Month

As part of this year's World Landscape Architecture Month celebration in April, the American Society of Landscape Architects (ASLA) is teaming up with EarthDay.org to sponsor The Great Global Cleanup 2021.

Throughout the month of April, ASLA members will join together to organize and execute local cleanup projects as part of the Great Global Cleanup's third official year.

"This April, ASLA is celebrating the work of landscape architects to help communities grow together, with each other and with their natural surroundings. Pollution is a prodigious issue in public open spaces – causing flooding, spreading illness, contaminating water sources, and at the root of a myriad of other problems," said Torey Carter-Conneen, CEO of ASLA. "We're incredibly proud to partner with EarthDay.org on the Great Global Cleanup initiative during World Landscape Architecture Month to combat this issue and support healthy, resilient, and sustainable open spaces for all."

For more information, click **here**.

American Water Resources Association

AWRA 2021 Virtual Summer Conference

July 19-21, 2021

Join us for our first-ever virtual AWRA Specialty Conference titled AWRA 2021 Summer Land and Water Specialty Conference. This conference will bring together stakeholders across multiple disciplines, types of organizations, and professions to address the design, integration, and implementation of the programs necessary to better connect land and water planning and policy.

Although this conference will be virtual, AWRA will uphold our long commitment to outstanding technical content and unparalleled opportunities for Community, Conversation, and Connections, the hallmark of AWRA meetings.

For more information, click **here**.

Geological Society of America

GSA Connects 2021

October 10-13, 2021

Portland, OR

At GSA Connects 2021 you will discover a dynamic meeting that surrounds you with the inspiration and opportunities for engagement you need to advance your geoscience career.

Join us 10–13 October for cutting-edge technical sessions, outstanding professional education, and inclusive networking opportunities that will broaden your geologic knowledge and connect you to our diverse geoscience community.

For more information, click **here**.

Society of Environmental Toxicology and Chemistry

SETAC North America 42nd Annual Meeting

November 14-18, 2021

Portland, OR

Building on the success of last year's meeting and embracing inclusivity and sustainability, we are planning a hybrid meeting that combines lots of in-person events for attendees in Portland, Oregon, with a virtual program for remote participants. SETAC will not require session chairs or presenters to attend the meeting in person. We will keep all participants updated as decisions regarding the format are made.

For more information, click **here**.

Renewable Natural Resources Foundation
6010 Executive Boulevard, Suite 700
North Bethesda, Maryland 20852 USA