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How Plastics Benefit Wildlife and the Environment

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Several proposals designed to end America's so-called addiction to plastics are currently pending in Congress. They include the Break-Free from Plastics Act (H.R. 2238, S. 984), sponsored by Rep. Alan Lowenthal (D-CA) and Sen. Jeff Merkley (D-OR),[1] and the Climate Leadership and Environmental Action for our Nation's Future, or CLEAN Future, Act (H.R. 1512), sponsored by Rep. Frank Pallone (D-NJ).[2] These bills' supporters indicate that this legislation will help society "break free from plastics pollution" with "massive reductions in single-use plastics."[3] Yet these measures are far more comprehensive, targeting more than single-use plastics, and the proposals are so extreme they could destroy the U.S. plastics industry.

While there are legitimate concerns about the impact of plastics litter on the environment, particularly wildlife, this legislation reflects a larger, radical-left agenda to cripple the U.S. fossil fuel industry. Synthetic plastics are made with byproducts of the petrochemical industry and thus, green activists would rather ban them completely than find workable solutions related to litter and plastics in the ocean.

This is the first of four papers that will detail why the anti-plastics agenda would do immeasurable harm to humanity as well as to wildlife. This paper focuses on how plastics have helped wildlife and the environment and demonstrates the devastating impact that would result if humans were to stop producing synthetic plastics and rely on "renewable" resources instead. The second paper addresses the value that plastics bring to humanity. The third addresses real environmental issues related to how we manage and dispose of plastic products and looks at ways to solve those problems. The final paper addresses why legislation before Congress will not solve real problems related to litter, but could destroy the U.S. plastics industry, forcing us to source plastic products from China and other countries with lower environmental standards.

What Are Plastics and How Are They Made? Before jumping into the details about plastics and wildlife, we need to better understand what exactly plastics are—both natural and synthetic forms. Plastics are made of polymers, which are long chains of the same small molecules—or monomers—that connect in repeating patterns. Their properties vary by the types of molecules involved and their arrangement.

Humans can extract polymers from nature—from plants and animals—or we can use petrochemicals to form them. Accordingly, polymers can be either synthetic (synthesized by humans) or natural (extracted from nature).

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Plastics fall within two broad categories: thermoplastics and thermosets.[4] Thermoplastics are materials that manufacturers can melt and reshape more than once, such as the plastics companies use to make bottles, utensils, straws, and many other items. Thermosets are plastics that remain solid and cannot be melted and remolded once they dry or cure, such as polyurethane or epoxy.

While all plastics are polymers, not all polymers are plastics. Some natural polymers are often referred to as "natural plastics" when they can perform similar functions as synthetic plastics, while other polymers, such as DNA and gelatin, are quite different. Natural polymers that serve functions similar to synthesized plastics include rubber, ivory and other animal horns, turtle shells, shellac, wool, cotton, silk, and cellulose, among other things. Such natural plastics are common. For example, even the protective casings of shellfish and cockroaches are considered natural plastics.[5]

For most of human history, humans relied on natural plastics to serve a wide variety of needs, using animal shells and horns to make combs, jewelry, and billiard balls; cotton and silk for clothing; rubber for waterproof finishes and raincoats; and shellac for protective coating on furniture and wire insulation during the early years of electricity.

Eventually, the world turned to synthetic forms of plastics, most of which are made using chemical byproducts from fossil fuel refining or processing. It is also possible to make some of these same synthetic plastics using sources other than fossil fuels—such as sugars or cellulose from plants—but that does not make the final product any different or better, and they are not necessarily more biodegradable.

Plastic products are the result of industrial recycling, using byproducts of the oil and gas industry to make valuable products. Inventor Alexander Parkes is credited with producing the world's first plastic in 1862 using cellulose from plants. Other businessmen eventually fashioned what became known as "parkesine" into combs and other consumer products. Today, manufacturers derive most synthetic plastics from petrochemicals to make a wide array of products, including plastic bags, packaging, bottles, medical devices, and many consumer goods. Manufacturers also make a wide range of textiles from synthetic polymers, including, nylon, rayon, spandex, acetate, and other fabrics. Companies can make these synthetic plastics using resources from various sources—including cellulose from plants—but they produce a large majority from petrochemicals.

The building blocks for many of these synthetic plastics are ethylene and propylene, both of which firms extract from crude oil refining and natural gas processing. Specifically, when companies process natural gas to remove impurities, they produce ethene and propane byproducts, which they send to "cracking facilities" that break up the chemicals into smaller molecules, including ethylene and propylene monomers. Similarly, oil refining facilities distill crude oil to separate out and create various chemical mixtures, such as gasoline, kerosene, diesel, heavy oil, and naphtha. They send naptha to cracking facilities that break it down further into various useful monomers, including ethylene and propylene.

Manufacturers use ethylene and propylene mainly to make plastics, but they use them to make other products as well. For example, ethylene is used to make ethylene oxide, which is used to sterilize medical supplies and to make antifreeze and other consumer products. Were they not used for plastics, they might become waste products unless other uses provided enough demand for them.

Plastic producers take ethylene and propylene to "polymerization" facilities that combine the chemicals into longer chains to make various types of plastic polymers called resins. The companies apply various processes and chemical additives to produce a wide variety of resins, each with different qualities related to clarity, strength, flexibility, heat resistance, and other characteristics. Once formed, polymerization plants chop the resins into pellets that they can sell to manufacturers who melt them down and make products. Manufacturers can melt resins and mold them into various thermoplastic products or they can apply various processes—high temperatures, pressure, or additives—to transform them into thermoset plastic products.

The type of resin a manufacturer uses to make a particular product is often noted on the bottom of the product with a number located inside a triangle composed of arrows. The industry uses these codes to assist in sorting for recycling, since most types of recycling require separation by plastic type. Some of the common resins are known by their acronyms and their identifying numbers include:

1. **PET or Polyethylene Terephthalate**. Manufacturers use this thermoplastic to make some polyester fabrics as well as the clear, rigid plastic containers used for such things as beverage bottles and food containers.
2. **HDPE or High-Density Polyethylene**. HDPE is a thermoplastic that manufacturers use to make milk bottles, detergent containers, thin plastic grocery carryout bags, and more.
3. **PVC or Polyvinyl Chloride**. PVC thermoplastics can make both rigid and flexible plastics suitable for a wide range of applications, including pipes and other home infrastructure, wire insulation, medical devices, and much more.
4. **LDPE or Low-Density Polyethylene**. Similar to, but more flexible than HDPE, this thermoplastic works for a wide range of products including packaging, medical devices, bags, toys, and more.
5. **PP or Polypropylene**. Manufacturers make both rigid or flexible polypropylene products for use as food packaging, straws, Tupperware, diapers, clothing and more.
6. **PS or Polystyrene**. Polystyrene is a thermoplastic that makes foam cups and containers, but manufactures also make rigid, clear, or colored polystyrene items. Some examples include plastic utensils and home construction materials such as plastic showers and tubs, petri dishes, consumer electronics, medical supplies, and more.
7. **Other**. Category seven is a catchall category covering a range of plastic products such as resins used to line food cans, nylon, and many others. Among these are thermoset plastics like polyurethane, epoxies, silicone, and fiberglass (a thermoset form of polyester).

Synthetic Plastics Benefit Wildlife. Many people assume that natural and renewable resources are always environmentally preferable to man-made, synthetic alternatives, but both the history and experience associated with plastics use demonstrates otherwise. Finding man-made or farmed alternatives—be it plastics or chickens—to products sourced in nature can reduce pressure on wild animals. Plastics have clearly played a large role in the survival of many species, a role that today, is often ignored.

Synthetic plastics replaced their natural counterparts to meet human needs because the synthetic versions proved less expensive and easier to access. The price conveys information about its environmental impact, reflecting the cost of energy, materials, and labor used to harvest, transport, and process a material into something useful. So, the final price indicates the amount of resources used and their scarcity in addition to how much we value them.

People might still think it is worth spending more for "environmentally better" natural products, but if we abandoned plastics altogether, the environmental impacts would be devastating. The following overview of the history, as well as examples, clearly demonstrate that without plastics, wildlife would suffer, and we would need to use far more resources to meet human needs.

Synthetic plastics reduce mankind's impact on wildlife populations in two main areas: They reduce the need to a) secure resources from animals in the wild, and b) farm renewable resources. The benefits of reducing the need to farm "renewable resources" are rarely considered and usually vastly underestimated. Indeed, as researcher Indur Goklany notes:

> The collective demand for land to meet humanity's demands for food, fuel, and other products of living nature is—and always has been—the single most important threat to ecosystems and biodiversity. Fossil fuel–dependent technologies have kept that demand for land in check.[6]

In a nutshell, reduced farming means there is more land available for wildlife, while production of synthetic plastics means wildlife populations are far less threatened by demand for natural plastics.

From Ivory to Bakelite. Consider the impact on wildlife related to the growing demand for elephant tusks, other animal horns, and tortoise shells. As societies industrialized and human populations grew around the turn of the 20th century, elephant tusks in particular faced high and growing demand. "The elephant's great enemy was the soaring popularity of ivory knife handles," and following that were "musical instrument keys, mathematical scales, dice, chessmen, billiard balls and the last but not least 'artistic earrings,'" notes Stephen Fenichell in his book *Plastic: The Making of a Synthetic Century*.[7]

At the time, as the game of pool gained new popularity, the demand for ivory to make billiard balls was particularly keen, and making balls from the tusks required a massive amount of ivory. Only one in 50 tusks presented the quality needed to make a single billiard ball, notes Fenichell, and as billiards grew in popularity the demand for ivory presented a serious threat to elephant populations. He explains:

> By the mid-1800s, big game hunters were expressing growing concern that there would soon be no more elephants left to kill. "In part of the northern province of Ceylon," reported the *New York Times*, in an urgent dispatch from the killing fields, "upon the reward of a few shillings per head offered by the authorities, 3,500 pachyderms [elephants and other horned animals] were dispatched in less than three years by the natives. [English factories at] Sheffield alone requires annually the slaughter of a large army of pachyderms, estimated some years ago at 22,000, to furnish ivory for the various articles produced in manufacturing establishments."[8]

During the 1860s, the high price of ivory led one of the nation's prime billiard ball retailers to run ads around the United States offering a $10,000 reward to anyone who could find a suitable substitute. With his eye on the prize, New York State resident and inventor John Wesley Hyatt developed a cellulous-based plastic billiard ball, inspired in part by Alexander Parkes's creation of celluloid-based parkinsine. However, both Parkes's and Hyatt's plastics did not resolve demand for ivory because celluloid plastics were highly flammable. In fact, Hyatt's pool balls would let off small explosions and loud bangs when they smacked together. Yet, Hyatt's and Parkes's efforts reflected and further inspired a larger trend among inventors to discover ways to synthesize plastics rather than focus on more limited and expensive sources from wildlife.[9]

Chemist Leo Baekeland's discovery of a synthetic alternative to ivory during the early 1900s greatly reduced pressure on elephants and other horned animals as well as tortoises and other creatures. Originally, his quest was to find a substitute for shellac's use for electric wire insulation.[10] Shellac, which also serves as a coating on wood furniture, was in high demand for wire at the turn of the century as the world industrialized, and prices climbed to more than a dollar per pound.[11] It was unlikely that the world supply of this natural substance—produced from the secretions of "lac bugs" in Asia—would be enough to meet growing demand, and there certainly would be both financial and environmental costs associated with vastly expanding supply through planting lac trees.

Baekeland's quest paid off in 1907, when he discovered that mixing phenol (carbonic acid) and formaldehyde made a moldable plastic. Baekeland's discovery, the first of its kind to go on the market, was a huge success.[12] Once molded, it produced a thermoset plastic, which forms into a hard substance that resisted heat and proved valuable for wire insulation and many other products including billiard balls, radios, television sets, clocks, lamps, combs, and more. Bakelite also became popular for making jewelry during the first half of the 20th century, and these vintage items have become part of many antique jewelry collections. The discovery of Bakelite opened what some call the beginning of "The Polymer Age."[13]

Following Baekeland's great discovery, other investors and researchers developed the science behind synthetic plastics that would lead to yet more discoveries. Of particular note was chemist Hermann Staudinger's discovery of what he called "macromolecules"—long-chained monomers of a high molecular weight—that we now refer to as polymers. During the 1920s, he demonstrated how chemical reactions could form these chains to produce various substances through polymerization. His work not only increased understanding about the nature of polymers, it opened the door to the development of modern plastics.[14]

The discovery of Bakelite and other plastics that followed continued to reduce pressure on wildlife during the 20th century. As population increased, industrialization expanded, and economies grew, the demand for plastic products inevitably intensified. And during World War II, demand for plastics to meet military needs was tremendous, as it proved valuable in the making of helmets, textiles for uniforms and parachutes, goggles, airplane parts, and other military equipment. As a result, the U.S. government invested heavily in plastics development, further advancing the plastics industry. As journalist Heather Rogers notes, "Among other public investments in polymers, the feds threw down a billion dollars for private companies to construct synthetics plants in cities across the country from Louisiana to Connecticut."[15]

Finding inexpensive, less environmentally impactful substitutes to natural plastics proved essential both to the war effort and to facilitate economic growth and improved quality of life for a larger share of humanity.

Many of the chemicals necessary to produce synthetic plastics also happened to be byproducts of fossil fuel production, which opened a treasure trove of affordable resources for making a wide range of consumer products. Making plastics from petrochemical byproducts—essentially recycling what would have become waste—meant that the final products proved much less expensive. The natural alternatives were costlier because they required more resources: land for farming or raising animals, wildlife horns, and other body parts, and energy and water for processing and transportation from remote regions. Yet eventually, chemists were able to make a vast array of plastics from these petrochemical byproducts that made a huge difference once they entered the market.

While some people remain critical of plastics because of environmental concerns, Bakelite and other plastics likely saved many species from endangerment or outright extinction. No longer would demand for myriad products depend on harvesting horns or shells from elephants, rhinoceroses, tortoises, and other animals. In his 2020 book, *Apocalypse Never*, environmental journalist Michael Shellenberger details how synthetic plastics helped save the hawksbill sea turtle, as well as elephants, stating: "We must also find a way to train ourselves to see the artificial product as superior to the natural one." [16]

The threats to elephants were not simply resolved by the introduction of plastics, of course, but plastics helped them survive long enough until other means of protection could be developed.

The main challenge was that the animals were owned in common—basically by no one, as they lived in the wild—so they had no one to protect them. When left in the wild without owners—or simply owned by the government—few people have a stake in protecting them. To farmers in regions where elephants are wild, the animals can become giant pests as they can quickly devastate farms, leaving communities with little to eat. In that case, the only value people see in the animals is for poachers seeking their tusks or meat.
Privatization and the creation of elephant preserves for safaris during the last several decades have proven the best means of protecting elephants.[17] Fortunately, the discovery of

synthetic plastics helped prevent the species from going extinct before such conservation efforts developed. That has not been the case for all species.

Consider the passenger pigeon, which once was among the most common birds in North America, with numbers ranging into the billions, but which by 1914 had become extinct. Americans hunted the birds for food, but also for its beautiful feathers, which were used for adorning women's hats. Had there been a synthetic substitute for the feathers, the birds might have fared better, and perhaps survived. And, of course, privatization of the bird—or farming them the way we farm chickens—would have helped even more.[18]

The discovery of Bakelite was just the first example of how plastics reduced stress on wildlife and the environment. Consider more examples, starting with shellac.

From Shellac to Polyurethane. Shellac is sourced mainly from forests in India, Thailand, and other Asian nations as a secretion from a female "lac bug." They secrete this resinous substance onto lac trees, which hardens to create a protective shell within which they can lay eggs and generate offspring in relative safety from predators.

This resin serves as the basis for making shellac for commercial markets, but making shellac is an arduous process. Historically, it involved mobilizing Indian peasants to gather the dead shells from trees and spend "untold hours melting the shells over wood fires in iron pots, painstakingly filtering the amber colored hot liquid to remove the leaves, bark, and insect bodies preserved inside," notes Fenichell.[19] During the late 19th century it took 150,000 lac bugs six months to secrete enough material to produce just one pound of shellac, note James and Lynn Hahn in their book *Plastics*.[20] Accordingly, supplies were limited, and prices soared as demand increased alongside industrialization and population growth. Shellac's final product also requires other processing and other chemical additives, depending on the final product. And transportation from remote parts of the globe to markets in other nations adds to the financial and environmental costs as well.

German chemist Otto Bayer discovered a shellac substitute—polyurethane—in 1937 when he was working to find a substitute for naturally sourced rubber. While Bayer's discovery did not replace rubber, polyurethane has become the primary alternative to shellac wood finishes. It also makes rigid and flexible thermoset plastic foams, with many valuable applications. Rather than sourcing shellac resins from remote forests, polyurethane can be made using byproducts from fossil fuel processing.

Today, polyurethane is in high demand for furniture and flooring finishes, yet some woodworking advice articles suggest people go back to shellac, which they assume is better for the environment.[21] But if everyone followed their advice, the demand for shellac would explode, which would have substantial environmental impacts. Rather than simply recycling byproducts from the petrochemical industry into polyurethane, naturally sourced shellac would demand a vast amount of land for trees and labor for accessing the resins, leaving less land for wildlife. Energy use would also increase substantially for processing and shipping the product around the globe.

Shifting back to shellac would also carry other environmental impacts. For example, processing shellac creates a waste product containing bugs, leaves, and branches saturated with the denatured ethyl alcohol necessary to clean and process shellac.[22] In addition, once mixed with alcohol and canned for consumer use, shellac's expected shelf life is only a few months compared to several years for polyurethane, so it could potentially increase product waste.[23] And in some forms, it requires waxing after application, which means consumption of more resources to maintain some shellac finishes.

From Natural to Synthetic Rubber. Bayer was not alone in working to find a synthetic substitute for rubber, and a formulation in 1930 by DuPont company scientists eventually gained commercial success.[24] At the time, people sourced all rubber from latex, a liquid drained from rubber trees that grow in tropical areas like the Amazon and Southeast Asia.

Initially, people used rubber to make bouncing balls, raincoats, and waterproof fabrics, among other things, but it had some serious limitations. In cold winter temperatures, natural rubber became a hard, brittle solid that cracked easily, while in summer heat it melted and became mushy. That changed in the 1840s when Charles Goodyear discovered the process of vulcanization—using heat and sulfur to make a stable, solid rubber.

By the mid-20th century, demand for vulcanized rubber soared thanks in large part to the growth of the automobile industry and World War II-related needs, yet there were (and remain) limits to how much natural rubber can be sustainably produced. It takes about seven years before a rubber tree can produce latex, which requires removing some bark and inserting a tap, and each tree releases only about half a cup per day on average.[25] In addition, during World War II, the United States lost access to rubber supplies as much was grown in Japanese-occupied territory in Asia. Fortunately, manufacturers learned how to make synthetic rubber using chemicals found in naphtha, a byproduct of crude oil refining. Were it not for the rapid development of the synthetic rubber industry to meet wartime needs, the United States would likely have lost World War II because rubber was essential to the production of tanks, battleships, telegraphs and other wiring, waterproof boots and clothing, and so much more.[26]

Today both synthetic and natural sources of rubber compete, with supply and demand determining prices. If the world had to rely solely on natural rubber, it would require far more large rubber plantations, which would reduce biodiversity of forested land for wildlife. In addition, natural rubber requires high energy and water use and produces air and water pollution related not only to production, but also to transportation around the globe. Synthetic rubber helps meet global demands with domestic production that does not require land for farming rubber trees and transportation from distant places.

From Leather and Silk to Vinyl and Nylon. Synthetic plastics have also revolutionized the textile industry. In fact, the emergence of synthetic textiles has greater environmental benefits than most people could ever imagine. For much of history, all textiles came from natural sources. Farming was required to produce cotton, silk, and jute and to feed the animals—cows, sheep, alpaca, and others—whose hides or coats were used for clothing.

Demand for natural textiles is much lower because they have been replaced with synthetic alternatives like nylon, polyester, and vinyl, leaving more land for wildlife.

In his book, *Plastics*, Norman Finkelstein highlights how synthetic leather use in automobiles has reduced the need for raising cows while allowing the auto industry to expand:

> In the early decades of the twentieth century, the company [Dupont] successfully marketed a leather substitute made of pyroxylin, which they called Fabrikoid, for automobile seats. Unlike natural leather, their synthetic material resisted grease, oil, perspiration, and mildew and was less expensive than the real thing. Now cows could join the growing list of animals whose lives were extended by the wonders of plastic. A DuPont advertisement explained, "Cow production could hardly keep up with car production ... so leather men were finding it difficult to meet the demand for automobile upholstery material."[27]

Similarly, creating silk from natural sources is a complex process that requires farming the fibers from the cocoons of silkworms that feed on Chinese white mulberries. Author Susannah Handley notes in her book, *Nylon: The Manmade Fashion Revolution*:

> A much-coveted luxury for many centuries, the source of the fiber and the method by which it could be spun and woven was shrouded in secrecy by the Chinese for 3,000 years after its discovery around 2600 BC.[28]

People in Italy and elsewhere eventually learned how to make silk themselves creating farms of mulberry trees and raising silkworms, but it does require land and hence has environmental consequences.

While people can produce silk sustainably to meet current consumer demand today, if there were no synthetic options as well, the amount of farming would need to expand—with dire environmental consequences. According to the Council of Fashion Designers of America (CFDA), it takes 3,000 cocoons to produce one yard of fabric, and one mature mulberry tree will produce enough foliage for 100 silkworms.[29] In other words, making silk requires many trees and a substantial amount of energy for transporting materials, silkworm rearing facilities, and production and dying processes. Accordingly, silk is expensive because it demands a significant amount of resources. The price, along with the fact that there are synthetic alternatives like nylon, keeps the demand for silk in check, reducing those environmental impacts associated with farming and silk production.

In 1934, Wallace Carothers and his colleagues working for DuPont discovered how to make nylon from coal, water, and air, and it has proven useful for making more than fabrics. Its first commercial application was for toothbrush bristles, which before then relied on plucking coarse hair from animals, such as wild boars. Thanks to nylon, we no longer need to hunt wild boars in far-off places like China to harvest the bristles. Plastic bristles are not only cheaper, they also perform better, staying firm unlike the natural fibers that would get mushy when wet.[30]

Indur Goklany provides an even larger view on the crucial role synthetic fibers play in reducing man's environmental footprint. He notes that today, about 60 percent of the world's textile needs are met with synthetic products:

> Because of the widespread use of synthetic fibers, skins and furs are widely regarded as outmoded, unfashionable, and unnecessary. This may be partly responsible for the rebound of beavers and other wildlife.[31]

Plastics Save Energy and Water and Make Less Pollution than Alternatives. The reason plastic products—be it bags, food packaging, or home siding—are often the most affordable option is because they often require far fewer resources to make than paper, metal, stone, or glass alternatives. For example, paper straws are as much as 10 times more expensive than plastic straws, according to packaging company PacknWood CEO Adam Merran.[32] As detailed below and in Appendix A, paper requires more resources—energy, raw materials, and water—to produce, while plastics essentially make use of byproducts associated with fossil fuels production.

These realities are reflected in the price, which is a key indicator of how many inputs a product requires as well as the scarcity of those resources. Yet, policy makers and environmental activists have a hard time understanding how pricing provides information about resource use and scarcity. Meanwhile, rather than rely on pricing alone, industry, academia, and government agencies have conducted numerous "life-cycle assessments" (LCA) to compare the environmental impacts of various plastics and alternative products. These studies consider each product's environmental impact from cradle (production) to grave (disposal), and they provide solid data policymakers should heed before banning plastics. LCA studies validate what price signals show: the lower priced plastic products do in fact have smaller environmental footprints compared to alternatives.

Appendix A lists a number of LCAs, and key findings related to environmental impacts. These studies, which span decades, consistently show that plastics are often better for the environment than other alternatives because plastics use less energy during production and transport. Plastic consumer goods like straws, foam cups, and utensils are less energy intensive to produce than alternatives like paper or aluminum. Production of paper and aluminum items requires more resources, creates more waste, and results in more pollution than the production of disposable plastic items.

Plastics' light weight makes them more energy efficient because heavier items require more fuel for transportation. In addition, many plastic products can perform the same functions as alternative products even though the plastics are composed of less material. For example, plastic grocery bags are far less bulky than paper bags, which means you can transport more bags in fewer trucks. According to one plastic bag retailer, if his company switched to paper bags rather than plastics bags to meet a state ban on plastic bags, he would need four to eight times more space to store them and make four to eight more truckloads to deliver them.[33]

Because of such factors, numerous studies show that thin plastic grocery bags are much more energy efficient to make and transport, and they release less pollution than most alternatives and make less solid waste. According to one LCA:

- Single-use polyethylene plastic grocery bags use 71 percent less energy than paper bags;
- Paper bags require 96 percent more water;
- Paper makes about 86 percent more solid waste than single-use grocery bags; and
- Single-use grocery bags generate 39 percent fewer greenhouse gas emissions than regular paper bags.[34]

Only when reusable bags are used many times do they yield any net environmental benefit and few people use them long enough. The more "natural" reusable cotton bags, in particular, are among the least environmentally sound. One Canadian study noted that cotton bags are "not recommended" because they require "between 100 and 2,954 uses for its environmental impact to be equivalent to the environmental impacts of the conventional plastic bag."[35]

Canadian researcher Martin Hocking produced one of the earliest and most telling life-cycle assessments demonstrating the environmental benefits of polystyrene foam cups. It found that reusable cups must be used many times more before they have a lower environmental impact because they require more energy to make as well as energy and water to clean. For example, a reusable ceramic cup must be used 1,006 times, a glass cup 393 times, and reusable hard plastic cup 450 times before any one of these products can match the environmental performance of the foam cup. Accordingly, if a reusable cup is likely to break or be thrown away before those many uses, it is worse for the environment than a foam cup, but it is better when used more.[36]

Of course, it is possible for ceramic and glass cups to be used many times and eventually yield benefits. How products are used also affects their environmental profile and, in some cases, a reusable cup make sense, while in others it might not. Hocking points out that in places like busy hospital cafeterias foam cups may make sense because people benefit from both their energy efficient profile and sanitary nature.[37]

Notably, foam cups far outperform paper cups in terms of energy and waste savings. A ceramic cup only would need to be used 39 times to match the environmental performance of disposable paper cups, compared to the 1,006 times necessary to match the foam cup's performance. A 2011 Franklin Associates study found that the average 16-ounce foam cup uses a third less energy, produces 50 percent less solid waste by volume, and releases a third less of greenhouse gases than a 16-ounce paper cup with a sleeve. Foam packaging also requires 20 to 30 percent less water than do paper alternatives.[38]

The excellent environmental performance related to much lower resource use of the foam cup is reflected in a much lower price. In fact, when New York City considered banning foam cups in 2013, an economic impact study showed it would cost businesses as much as $100 million a year to switch to paper cups.[39] Unfortunately, many state and local governments have banned foam cups, such as a recent statewide ban in Maine,[40] forcing consumers to switch to paper based on the assumption that paper is more biodegradable. Yet, in a landfill, little if anything degrades and paper takes up more space than foam.

Paper cups are also not necessarily more recyclable, because they often have thin plastic or wax linings to ensure they can hold liquids. Most end up in a landfill, while foam cups, when pressed under other trash, will take up much less landfill space.

Plastic packaging also often outperforms alternative packaging when it comes to the environment. For example, studies conducted by a consulting organization known as Trucost for the United Nations and for the American Chemistry Council (ACC) found that switching from plastic packaging to other materials would not be advisable. A company representative notes in *Chemical and Engineering News* that the study demonstrated that switching from plastics packaging to alternative materials "wouldn't help at this point, given the environmental costs of the alternative materials. It would make things worse."[41]

In particular, the ACC-commissioned study found:

> Replacing plastic with alternative materials in common consumer goods applications using current technology is unlikely to reduce environmental costs at the sector level. The environmental costs of alternatives are estimated to be almost four times that of plastics. The higher environmental costs of alternatives to plastic are driven by the poorer material efficiency of these materials when used in common consumer goods applications—on average, replacing one metric ton of plastic requires 4.1 metric tons of alternatives materials across the sector.[42]

Clearly, plastics play an important role in conserving energy and water and reducing other environmental impacts when compared to alternatives. Life cycle studies consistently reveal such realities—information that has long been conveyed in plastics' affordable prices.

Conclusion. While many people recognize that plastics have made life easier and more convenient, fewer consider the positive impacts they have on the environment, both for wildlife and regarding resource use. Unfortunately, these realities are often left out of policy debates regarding plastics' impact on the environment. As a result, policy prescriptions often focus on bans and regulations that would ultimately undermine environmental goals.

This paper provides just a sampling of how synthetic plastics have helped to conserve energy and water and to reduce pressures on wildlife populations, the need to convert more land to farming, and overall solid waste volumes. Consider what the planet would look like if all plastics used for rubber, textiles, and wood finishes had to be sourced from renewable resources. We would need lot of land to expand rubber plantations, lac wood forests, mulberry trees, and more. And if all our consumer products had to be made from natural plastics, we would have to set aside land to raise and domesticate animals and farm more land to grow food for them. If we switched to paper over plastic, we would need more forests to harvest timber, and shifting to metal food containers over plastic would require more mining. As a result, we would need more pesticides, water, and energy to access plastics from renewable resources. And while nature can coexist with farming, we would not have much land left for wildlife preserves, parks, and other places that offer biodiversity.

Surely that is not the world that policy makers seek when looking to address real environmental problems related to plastics litter on land and in the ocean. Solutions to those problems do not require we throw the baby out with the bathwater by banning products that have so many demonstrated benefits. Fortunately, as the third paper in this series will show, solving plastics pollution can be achieved without bans and regulations. But first, paper two in this series will examine how plastics have vastly improved life for humans as well.

Notes

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[1] H.R. 2238/S. 984 – Break Free from Plastic Pollution Act of 2021, 117th Congress, First Session, https://www.congress.gov/bill/117th-congress/house-bill/2238; https://www.congress.gov/bill/117th-congress/senate-bill/984/all-info.

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