PLASTIC WASTE IN LOS ANGELES COUNTY

IMPACTS, RECYCLABILITY, AND THE POTENTIAL FOR ALTERNATIVES IN THE FOOD SERVICE SECTOR

UCLA Luskin
Center for Innovation

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DISCLAIMER

In the interest of soliciting candid, fact-based information, all individuals and entities interviewed for this report have been guaranteed confidentiality.

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definition of terms

Biodegradable: Disposable items that are certified to break down in an appropriate environment within a certain time frame based on physical disintegration to pieces below a certain size and chemical decomposition, but which may leave behind certain nonorganic residues.

Bioplastic: Plastic polymers derived from naturally occurring organic compounds such as plant sugar, as opposed to petroleum.

Compostable: Disposable items that are certified to break down in an appropriate environment within a certain time frame based on physical disintegration to pieces below a certain size and chemical decomposition, resulting in solely organic matter. A more stringent classification than biodegradable.

De Facto Recyclability: The degree to which a given product is economically viable for recovery and processing to be used in the manufacture of a new item based on a holistic consideration of its features, including material properties, contamination, and sorting processes.

Food Service Ware: Items used to package and serve food and beverages by food service vendors (e.g., restaurants, food trucks, fast-food and fast-casual establishments). Includes plates, trays, bowls, clamshell containers, cups, lids, and accessory items like utensils, straws, and condiment packages.

Microplastics: Traditional petroleum-based plastic fragments measuring less than 5 millimeters in length that have been broken down over time by natural processes including ocean currents, photodegradation, oxidation, and hydrolysis.

Phthalates: Chemical additives used to make plastic resins more flexible and durable — also termed plasticizers.

Plastic: A broad class of versatile and durable carbon-based polymers derived from petroleum.

Recycled: When a product that has entered the waste stream is recovered by a material recovery facility, processed into its material components, and used in the manufacture of a new product.

Reusable: Items that are manufactured and sold with the intent of fulfilling their intended purposes multiple times before disposal.

Single-use: Items that are manufactured and sold with the intent of being used once before being discarded and entering the waste stream.

Technical Recyclability: The degree to which a given product is capable of being recovered and processed to be used in the manufacture of a new item based on its material properties, but not considering factors such as economic viability or contamination.

100% Fiber-based: Disposable items made from naturally occurring plant fibers such as bagasse (sugarcane or sorghum pulp) and bamboo.

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executive summary

In August 2019, the Los Angeles County Board of Supervisors unanimously adopted the OurCounty Sustainability Plan, a broad, regional strategy for transitioning the County to a more sustainable future. Action 107 of the Plan calls for the County, in cooperation with the City of Los Angeles, to phase out single-use plastics. In October 2019, the Board passed a motion directing the Los Angeles County Chief Sustainability Office to contract with the University of California Los Angeles (UCLA) Luskin Center for Innovation to study the issues of plastic waste, processing, recyclability, and alternatives in the County, and to use the resulting study to inform the drafting of an ordinance addressing plastic waste.

This report analyzes the impacts of plastic production and waste across several categories and explores the state of the Los Angeles County waste landscape. We discuss the technical aspects of plastics and their *de facto* recyclability, dependent on their resin type and several other factors. Finally, we analyze the potential benefits and drawbacks of adopting alternatives to single-use plastic food service ware, and discuss the lessons learned by jurisdictions that have adopted such policies. The conclusions of this report are based on an extensive review of academic research and numerous in-depth interviews with facility operators, waste industry experts, government officials, and product manufacturers, along with information provided by stakeholder groups.

Our key findings are:

- Available evidence suggests that there are adverse environmental, economic, energy-related, and human health-related impacts associated with plastic production and plastic waste in Los Angeles County. Single-use plastic food service ware is a contributing factor to all these impacts, and its outsized representation in litter suggests a particularly significant impact in the environmental sphere, the area for which impacts in Los Angeles County appear most acute.
- While all types of plastic resins are technically recyclable, a majority are not actually recycled. This difference in technical versus *de facto* recyclability is

driven by a variety of factors including material properties, product size, contamination from food residue and other substances, and market conditions.

- Only High-Density Polyethylene (HDPE, Code 2) products and Polyethylene Terephthalate (PET, Code 1) bottles are currently commonly recycled in Los Angeles County.
- Current recycling policies and practices do not effectively address the adverse impacts associated with single-use plastic food service ware. No recovery facility serving Los Angeles County currently recycles plastic food service ware, primarily due to issues of food residue contamination, product size, and product material.
- All available evidence suggests that replacing single-use plastic food service ware with reusable ware (e.g., multiuse dishware, cups, and utensils) will reduce the negative impacts of plastic waste in Los Angeles County. Expected effects include a reduction in the generation of nonrecyclable plastic solid waste, a decrease in the prevalence of plastic litter, and fiscal benefits to vendors, waste management operators, local governments, and ratepayers.
- In the food service sector, the adoption of compostable ware presents potential benefits, including lower net lifetime environmental impact and higher food waste diversion rates. Available evidence suggests that, of the potential alternatives, 100% fiber-based products without chemical treatments will produce the best outcome. Managing this transition will require ensuring the selection of products with a lower lifetime environmental impact than their non-plastic counterparts and expanding disposal options (e.g., composting infrastructure).
- The experiences of jurisdictions interviewed indicate that policies restricting plastics have been effective at reducing the adverse impacts of plastic waste with no reported negative economic impacts. These jurisdictions with instituted policies have provided avenues for vendors to claim exemptions for financial hardship, but the rate at which vendors have applied for such exemptions is very low, and only a handful have been granted to date.

Cleaning up: Litter cleanup and prevention efforts, property damages, and loss of tourism/industry revenue can be costly for municipalities and residents.
Photo credit: iStock / South_agency

I. introduction

In August 2019, the Los Angeles County Board of Supervisors unanimously adopted the OurCounty Sustainability Plan, a comprehensive strategic document outlining the County's approach to the future of sustainability in the region. Action 107 of the Plan calls for the County, in cooperation with the City of Los Angeles, to develop an equitable strategy to phase out single-use plastics.[1]

In October 2019, the Board adopted a motion directing the Chief Sustainability Office to contract with researchers at the University of California Los Angeles (UCLA) Luskin Center for Innovation to study the issue of plastic food service ware waste in the County. The study's purpose is to research the state of single-use plastics in the waste stream, especially food service ware, in order to aid the County in drafting an ordinance to reduce plastic waste.

This report contains the findings from that study. We first examine the broad impacts of plastic production and waste with respect to the environment, the economy, energy, and human health. This is followed by an overview of the Los Angeles County waste landscape: the various facilities and infrastructure that process waste in the region, the proportions of materials, and how recent developments in the market have caused significant disruption in how plastics are recycled. We then provide a background on the technical aspects of plastics — including properties and common uses of the various types — which are highly relevant to how they are recycled, if at all. From here we progress to an in-depth discussion on the *de facto* recyclability of plastics in Los Angeles County, discussing the fundamentals of the recycling process and how recyclability varies across different plastic types and products. We then discuss the state of alternatives to plastic within the food service sector, focusing on how reusable and compostable food service ware compares to plastic with regard to its environmental and economic impacts, along with other relevant factors. Last, we discuss the degree to which policies restricting plastic have proliferated in California in recent years and the key takeaways from implementing jurisdictions.

1 Los Angeles County Chief Sustainability Office. OurCounty. 2019. Retrieved from https://ourcountyla.org/strategies/strategy-9a?goal=836

II. analyzing the impacts of plastics

Plastics play a major role in everyday use. However, their negative impacts spanning *environmental, economic, energy, and health* sectors are reason for critical concern. The effects of these impacts are noted first and foremost in order to further contextualize the role of plastic in the waste stream and the need for respective regulation.

This section relies on an extensive literature review to first examine the harm marine environments face as a result of plastic litter — most commonly originating inland — polluting coastlines and oceans. Microplastics specifically, and the subsequent danger they present to all ecosystems, are further discussed.

Our analysis then transitions to how communities and economies are negatively affected, focusing on both direct and indirect losses cities suffer as a result of plastic debris. The millions of California taxpayer dollars allocated annually toward litter cleanup and prevention efforts are recognized as the primary fiscal cost of the state of plastic waste in the region. We also reference the energy-intensive nature of plastics and their reliance on nonrenewable energy sources for production. As production of disposable plastics grows, these impacts can be expected to increase significantly without immediate intervention.

Last, we examine the health impacts associated with plastics consumption. This sector necessitates further research in certain areas, especially concerning styrene's recent identification as a potential carcinogen.[2] Plastic chemicals that have been proven to threaten human health as endocrine disruptors (BPA and DEHP) are also examined.

Key Findings:

- Plastic is the primary source of land litter in California, making up seven of the top 10 litter products found on beaches, with four being food service ware.[3]
- Plastic litter infiltrates City drainage systems and accrues in landfills with a lifespan likely lasting centuries.[4]
- Urban runoff channels millions of tons of debris into oceans per year, threatening invaluable natural habitats and marine life.[5]
- Coastal cities incur significant economic costs as a result of litter cleanups and prevention efforts.
- Polluted shorelines lead to indirect costs to communities including losses in tourism revenue and damage to recreational/aesthetic values of the coastal environment.[6]
- Traditional petroleum-based plastics rely on nonrenewable energy sources for production and recovery, contributing to an increasing global carbon footprint throughout their lifecycle.[7]
- Recent studies have revealed that common chemicals found in plastics including styrene present a poten-

2 p65list091319.pdf. (n.d.). https://oehha.ca.gov/media/downloads/proposition-65//p65list091319.pdf
3 California Coastal Commission. California Coastal Cleanup Day History. Retrieved from https://www.coastal.ca.gov/publiced/ccd/history.html
4 Jahn, A., Kier, B., & Stickel, B.H., (2013). *Waste In Our Water: The Annual Cost to California Communities of Reducing Litter That Pollutes Our Waterways*. Kier Associates. Retrieved from https://www.nrdc.org/sites/default/files/oce_13082701a.pdf
5 National Oceanic and Atmospheric Administration (NOAA), "Marine Debris: Frequently Asked Questions." Retrieved from marinedebris.noaa.gov/info/faqs.html
6 Midbust, J., Mori, M., Richter, P., & Vosti, B. (2014). Reducing Plastic Debris in the Los Angeles and San Gabriel River Watersheds (MESM Report). Bren School of Environmental Science & Management: University of California, Santa Barbara.
7 Thompson, R.C., Moore, C J., Saal, F.S. vom, & Swan, S.H. (2009). Plastics, the environment and human health: current consensus and future trends. Philosophical Transactions of the Royal Society B: Biological Sciences. Retrieved from https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2009.0053

Cleaning up microplastics on the beach:

Over 8 million tons of plastic enter the oceans each year, degrading these and nearby natural habitats, and endangering fish, birds, turtles, and marine mammals who mistake microplastics for food.

Photo credit: iStock / DisobeyArt

tial threat to human health, yet this field necessitates continued research and analysis.

- Bisphenol A (BPA) and di(2-ethylhexyl) phthalate (DEHP) plastic chemicals have also been regarded as hazardous to human health, particularly impacting the endocrine system.

Aquatic and Marine Impacts

Aquatic ecosystems, including rivers, lakes, ponds, streams, springs, and bays, provide our planet with critical benefits. The aquatic environment provides a habitat for an array of fish and other wildlife, acts as a water source for irrigation and drinking water, produces natural food sources, and helps to prevent and store flood water.[8] The vast marine environment, in addition to these benefits, also regulates our climate by transporting heat, produces over half of the world's oxygen, stores carbon dioxide, provides global economic goods and services, and also acts as a primary source of global transportation for trade and recreation.[9] Aquatic and marine environments additionally contribute invaluable natural beauty to our world.

Over 8 million tons of plastic enter the oceans each year, degrading these natural habitats and threatening wildlife species, tourism, and commercial fisheries.[10] The California Coastal Commission reports that plastics make up seven of the top 10 litter products found on beaches, with four being food service ware.[11] The Marine Debris Database produced by the nonprofit Heal the Bay corroborates these results, showing that from 1999 to 2019, plastic products were approximately 45% of the litter found on beaches.[12] Officials of both coastal cities interviewed for this report noted marine impacts as the *prime motivator* for their respective plastics ordinances.

Of crucial concern here is the sizable portion of single-use plastic waste that is littered. Inland litter is carried by rainwater and wind to gutters and storm drains, clogging systems that contribute to street

[8] Virginia Polytechnic Institute and State University. (2009). *Aquatic Habitats: Homes for Aquatic Animals* (Sustaining America's Aquatic Biodiversity). Virginia Cooperative Extension. Retrieved from https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/420/420-522/420-522_pdf.pdf

[9] National Oceanic and Atmospheric Administration (NOAA), "Why should we care about the ocean?" Retrieved from https://oceanservice.noaa.gov/facts/why-care-about-ocean.html

[10] United Nations Environment Programme. (n.d.). *Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations*. UNEP.

[11] California Coastal Commission. California Coastal Cleanup Day History. Retrieved from https://www.coastal.ca.gov/publiced/ccd/history.html

[12] Heal the Bay. Marine Debris Database. Retrieved from http://mddb.healthebay.org/AnalysisWizard.aspx

flooding and traffic congestion, while leading debris into rivers, lakes, and the ocean. Researchers at the University of California Santa Barbara Bren School conclude that plastic debris collected in river and beach cleanups accounts for about half of all the trash amassed in California, with close to 50% being single-use plastic packaging items.[13] The researchers further report that urban runoff is the primary source of marine debris in the Los Angeles and San Gabriel River Watersheds, with litter recognized as the primary source of trash within urban runoff.[14] Plastic litter items subsequently impose high cleanup costs incurred by taxpayers, with Los Angeles County having spent $18 million in 2007 on litter prevention, cleanup, and education.[15]

Over time, natural ocean currents, photodegradation, oxidation, and hydrolysis break plastics down into fragments termed microplastics, which measure less than 5 millimeters in length.[16] A wide range of fish, birds, turtles, and marine mammals can ingest these particles, while larger items pose the risk of entanglement.[17] These impacts compromise natural processes and threaten wildlife with laceration or death.[18] The buoyancy of most plastic resins also causes debris to accrue on the sea surface. Moreover, marine organisms can inhabit floating plastic, allowing for both the transport of invasive species and buildup of sunken debris on the seafloor.[19]

Chemical leaching is also cause for concern. Additives including phthalates and BPA affect reproduction and impair development in a range of marine species.[20] Toxins from plastics can subsequently enter the food chain, posing a potential threat to human health.[21] Microplastics have been found in fish from California fish markets as well as in both drinking and bottled water.[22]

Economic and Community Impacts

Significant economic costs are incurred on coastal communities in both direct and indirect expenses related to plastic debris. With waste management responsibility falling on county and/or city public agencies, community residents are directly impacted regardless of their proximity to the ocean. Litter cleanup and prevention efforts, property damages, and tourism/industry revenue loss prove costly for municipalities and residents.[23]

The California Recycling and Plastic Pollution Reduction Act of 2020 reported that state taxpayers pay close to $420 million each year in beach cleanup and prevention efforts across all waste categories, with plastic items routinely identified as the most common litter type in coastal litter inventories.[24] Presumably, this cost can be lessened by improved waste management practices and consumer awareness. The nonprofit Natural Resources Defense Council further reported that the largest California communities spend an average of up to $4.4 million in annual street sweeping and $2.3 million in manual land litter cleanup.[25]

13 Midbust, J., Mori, M., Richter, P., & Vosti, B. (2014). *Reducing Plastic Debris in the Los Angeles and San Gabriel River Watersheds* (MESM Report). Bren School of Environmental Science & Management: University of California, Santa Barbara.

14 Ibid.

15 Los Angeles County Department of Public Works. An Overview of Carryout Bags in Los Angeles County. 2007. P. 11. https://ladpw.org/epd/pdf/PlasticBagReport.pdf

16 Midbust, J., Mori, M., Richter, P., & Vosti, B. (2014). *Reducing Plastic Debris in the Los Angeles and San Gabriel River Watersheds* (MESM Report). Bren School of Environmental Science & Management: University of California, Santa Barbara.

17 Ibid.

18 Thompson, R.C., Moore, C.J., Saal, F.S. vom, & Swan, S.H. (2009). Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences*. Retrieved from https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2009.0053

19 Ibid.

20 Ibid.

21 Devasahayam, S., Raman, R., Chennakesavulu, K., & Bhattacharya, S. (2019). Plastics-Villain or Hero? Polymers and Recycled Polymers in Mineral and Metallurgical Processing-A Review. *Materials (Basel, Switzerland)*, *12*(4), 655. doi:10.3390/ma12040655

22 California Recycling and Plastic Pollution Reduction Act of 2020 (n.d.). Retrieved from https://caaquaculture.org/wp-content/uploads/2019/11/Plastics-Initiative.pdf

23 Jahn, A., Kier, B., & Stickel, B.H., (2013). *Waste In Our Water: The Annual Cost to California Communities of Reducing Litter That Pollutes Our Waterways*. Kier Associates. Retrieved from https://www.nrdc.org/sites/default/files/oce_13082701a.pdf

24 Ibid.; California Recycling and Plastic Pollution Reduction Act of 2020 (n.d.). Retrieved from https://caaquaculture.org/wp-content/uploads/2019/11/Plastics-Initiative.pdf

25 Jahn, A., Kier, B., & Stickel, B.H., (2013). *Waste In Our Water: The Annual Cost to California Communities of Reducing Litter That Pollutes Our Waterways*. Kier Associates. Retrieved from https://www.nrdc.org/sites/default/files/oce_13082701a.pdf

Multiple studies have also been conducted to estimate the intangible costs associated with plastic waste specifically. For instance, a 2019 study quantified the degradation to marine ecosystems per ton of plastic.[26] Researchers estimated this loss at $33,000 per ton of waste, revealing the potential fiscal impact of debris on marine environments.[27] Further research has additionally focused on the loss of tourism revenue resulting from plastic debris. When washed ashore, plastic litter visually impairs shorelines and pollutes public space.[28] To avoid littered beaches, visitors and residents may instead choose to travel to cleaner beaches, even at additional expense. The National Oceanic and Atmospheric Administration revealed that reducing marine litter by approximately 25% would save Orange County residents, for example, close to $32 million in travel time savings.[29]

Energy Impacts

Plastic production relies on nonrenewable energy sources including feedstock derived from petroleum.[30] While the U.S. Energy Information Administration is "unable to determine the specific amounts or origin of the feedstocks that are actually used to manufacture plastics in the United States," these processes have been reported to use close to 4% of global oil yields, with a proportional amount of energy used in the process.[31] With over one-third of plastic production dedicated specifically to plastic packaging, the rise in single-use plastic applications is likely to lead to significant increases in oil consumption.[32] Bottled water consumption in the United States alone rose 284% between 1994 and 2017, with 67% of all sales being single-use water bottles.[33]

The California Recycling and Plastic Pollution Reduction Act of 2020 notes that global plastic production is estimated to at least triple by 2050, which would encompass 20% of all fossil fuel consumption.[34] Ultimately, the energy-intensive nature of plastic manufacturing, production, and recovery further contributes to greenhouse gas emissions and a global reliance on fossil fuels.

Health Impacts

Adverse human health effects related to plastics have been studied more recently, with specific focus on the chemical styrene. This chemical has been determined to be a carcinogen by California's Office of Environmental Health Hazard Assessment and is of particular concern when heated.[35] Many studies emphasize negative effects of occupational, high-level exposure to styrene.[36] However, in terms of average human exposure, more robust scientific study on the topic is essential in order to further understand impacts.

Styrene is the main compound of polystyrene — a plastic type commonly used to make disposable food service ware. Polystyrene's foamed version (expanded polystyrene) is commonly used to make single-use clamshells

26 Beaumont et al. (2019). *Global ecological, social and economic impacts of marine plastic*. Elsevier: Plymouth Marine Laboratory.

27 Ibid.

28 Jahn, A., Kier, B., & Stickel, B.H., (2013). *Waste In Our Water: The Annual Cost to California Communities of Reducing Litter That Pollutes Our Waterways*. Kier Associates. Retrieved from https://www.nrdc.org/sites/default/files/oce_13082701a.pdf

29 Industrial Economics Incorporated. Assessing the Economic Benefits of Reductions in Marine Debris: A Pilot Study of Beach Recreation in Orange County, California. 2014. P. 3. Retrieved from https://marinedebris.noaa.gov/report/economic-study-shows-marine-debris-costs-california-residents-millions-dollars

30 Thompson, R.C., Moore, C.J., Saal, F.S. vom, & Swan, S.H. (2009). Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences*. Retrieved from https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2009.0053

31 How much oil is used to make plastic? (n.d.). Retrieved from https://www.eia.gov/tools/faqs/faq.php?id=34&t=6; Thompson, R.C., Moore, C.J., Saal, F.S. vom, & Swan, S.H. (2009). Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences*. Retrieved from https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2009.0053

32 Ibid.

33 Goldsberry, C. (2018, December 20). Pressure to reduce consumption of single-use plastic packaging will continue into 2019. Retrieved January 10, 2020, from https://www.plasticstoday.com/packaging/pressure-reduce-consumption-single-use-plastic-packaging-will-continue-2019/8501551360001

34 California Recycling and Plastic Pollution Reduction Act of 2020 (n.d.). Retrieved from https://caaquaculture.org/wp-content/uploads/2019/11/Plastics-Initiative.pdf

35 p65list091319.pdf. (n.d.). Retrieved from https://oehha.ca.gov/media/downloads/proposition-65//p65list091319.pdf

36 NTP (National Toxicology Program). 2016. Report on Carcinogens, 14th Edition.; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. Retrieved from https://ntp.niehs.nih.gov/go/roc14; Huff, J., & Infante, P.F. (2011). Styrene exposure and risk of cancer. Mutagenesis, 26(5), 583–584. https://doi.org/10.1093/mutage/ger033

and containers. Occupational studies have found that workers exposed to styrene have increased risks of lymphoma, leukemia, lung tumors, and pancreatic, urinary bladder, prostate, and colorectal cancers.[37] Elevated risks of lymphohematopoietic cancer have also been found among workers with high levels of styrene exposure.[38] According to the U.S. Environmental Protection Agency, chronic long-term exposure to styrene can affect the central nervous system, resulting in headaches, fatigue, weakness and depression.[39]

Due to extensive research, several agencies have consequently listed styrene as a hazardous substance. The International Agency for Research on Cancer, an intergovernmental agency that is part of the World Health Organization, recently updated its classification for styrene, determining that it is *probably* carcinogenic to humans.[40] This is an increase in the severity classification for the compound from its previous status as *possibly* carcinogenic. The National Toxicology Program, an interagency program within the U.S. Department of Health and Human Services, has also defined styrene as "reasonably anticipated to be a human carcinogen" due to limited evidence from human studies and ample evidence from animal studies.[41] In 2016, California's Office of Environmental Health Hazard Assessment listed styrene as a human carcinogen on California's Proposition 65 list.[42]

Research has shown that styrene is of particular concern for consumers because, when exposed to high temperatures, it can migrate from food packaging into the food it contains.[43] The level of styrene migration that occurs from food packaging highly depends on the level of fat content of the food as well.[44] The higher the fat content and the higher the temperature, the higher the level of styrene that is released.[45]

Several studies have identified additional plastic chemicals that threaten human health, including BPA and DEHP. BPA is the main component found in more durable plastics termed polycarbonates, commonly used to make *reusable* water bottles, baby bottles, and food containers. BPA can also be used as an additive for common plastics in order to strengthen material.[46] DEHP is another additive in many polyvinyl chloride products, often used to make materials more flexible and plastic-like.[47] Both chemicals have been determined to be endocrine disruptors, interfering with natural hormone function in the body and producing severe adverse effects in humans.[48] Despite the increase in BPA and DEHP-free products, BPA and DEHP still exist in some consumer products. However, they are largely absent from single-use food service ware.

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37 NTP (National Toxicology Program). 2016. Report on Carcinogens, 14th Edition.; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. Retrieved from https://ntp.niehs.nih.gov/go/roc14

38 Ibid.

39 US. EPA. styrene.pdf. (n.d.). Retrieved from https://www.epa.gov/sites/production/files/2016-09/documents/styrene.pdf

40 Aarhus University. (2018, May 30). After 40 years in limbo: Styrene is probably carcinogenic. *ScienceDaily*. Retrieved December 12, 2019, from www.sciencedaily.com/releases/2018/05/180530113105.htm

41 NTP (National Toxicology Program). 2016. Report on Carcinogens, 14th Edition.; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. https://ntp.niehs.nih.gov/go/roc14

42 p65list091319.pdf. (n.d.). Retrieved from https://oehha.ca.gov/media/downloads/proposition-65//p65list091319.pdf

43 Tawfik, M.S., & Huyghebaert, A. (1998). Polystyrene cups and containers: styrene migration. Food Additives and Contaminants, 15(5), 592–599. https://doi.org/10.1080/02652039809374686

44 Ibid.

45 Ibid.

46 Manikkam, M., Tracey, R., Guerrero-Bosagna, C., & Skinner, M.K. (2013). Plastics Derived Endocrine Disruptors (BPA, DEHP and DBP) Induce Epigenetic Transgenerational Inheritance of Obesity, Reproductive Disease and Sperm Epimutations. PLOS ONE, 8(1), e55387. https://doi.org/10.1371/journal.pone.0055387

47 Ibid.

48 Halden, R. U. (2010). Plastics and health risks. Annual Review of Public Health, 31, 179–194. Retrieved December 16, 2019, from https://doi.org/10.1146/annurev.publhealth.012809.103714; Endocrine Disruptors. (n.d.). Retrieved December 16, 2019, from https://www.niehs.nih.gov/health/topics/agents/endocrine/index.cfm

III. the problem of waste in Los Angeles County

To assess plastic waste in Los Angeles County, it is crucial to examine the waste management structure and waste stream. Different types of facilities process different types of materials. Historically, the County has relied on both private and public firms that operate materials recovery facilities, or MRFs, for waste processing. Composting facilities have traditionally played a lesser role in waste management, but recent industry changes will require increased reliance on these facilities.

This section is based primarily on interviews with waste management experts and is supplemented by information from County reports. It discusses waste management in Los Angeles County, the materials in the waste and recycling stream, and the impact of China's latest waste policy.

Key Findings:

- MRFs that sort and bale residential and commercial waste are the predominant waste processing operators in Los Angeles County.
- Many complex moving operations within the waste stream lead to a significant portion of waste being sent to landfill sites as convenient and economic solutions, yet plastic waste persists in landfill environments for up to centuries.
- Organic waste including many disposable plastic alternatives requires processing at composting facilities but insufficient composting infrastructure currently exists in the County.
- Plastics prove the most challenging material within the waste stream in terms of recovery limitations and disposal as litter.
- Recent Chinese policy imposing import restrictions have upturned the global recycling industry. The County has been severely impacted with where it can export regional waste but MRFs noted that the policy merely heightened existing problems.

Who Manages Waste in Los Angeles County and How?

The primary waste facilities in Los Angeles County for managing the recycling stream and some mixed-waste processing are materials recovery facilities (MRFs). These facilities receive waste from residential, commercial (including multifamily residences), or industrial sources. Waste is sorted and baled by material type, and ultimately sent to one of the following:[49]

- **A remanufacturing facility** accepts baled recyclable materials to turn into products or packaging.
- **A secondary MRF** can serve as a second line of defense after waste is sorted by the primary facility. Materials that would otherwise be destined for landfill can instead be recaptured. There is only one secondary MRF, Titus MRF Services, currently operating in Los Angeles County.
- **Waste-to-energy processing** combusts waste in order to produce and recover energy. These processes further divert waste from landfills.
- **Landfills** are sites where the majority of leftover materials are sent. Landfilled waste is layered up to hundreds of feet beneath the ground and is the oldest

[49] Los Angeles County Department of Public Works (2018). Polystyrene Food Service Ware in Los Angeles County. (2018). Retrieved from http://file.lacounty.gov/SDSInter/bos/supdocs/115952.pdf

form of waste treatment.[50] There are approximately 18 landfill sites operating in Los Angeles County.[51] Strong resistance to degradation allow all common plastic types to persist in landfills for centuries.

Sorting operations vary considerably depending on the MRF and the inputs received. Facilities either operate with mixed or presorted inputs. Mixed MRFs receive an aggregated waste stream of materials and must sort them accordingly. However, the majority of waste facilities in L.A. County receive presorted waste, also known as source-separated, which is the result of well-established two- or three-bin recycle collection systems. Even when receiving presorted recyclables from jurisdictions with bin systems, facilities must further sort by material type (e.g., plastic, cardboard). From the front end, it is important that materials are going into the right bins or trucks to ease the challenge of sorting at subsequent MRFs. There are approximately 55 large facilities in the County that process over 100 tons of waste per day.[52] This includes both MRFs and transfer stations, which consolidate waste picked up from garbage trucks.

Generally, MRFs receive paper, metals, glass, and plastics and some receive organic waste (e.g., food waste, yard waste, and plant-based food service ware). However, organic waste is not ideal to be mixed with those other materials for MRFs to process because it can contaminate the other materials and can be difficult to separate from other waste types.

It is more ideal for organic waste to be collected in a separate stream and sent to a composting or digestion facility; these facilities also play an important role in the County's waste structure. Based on our discussions with industry experts, a very limited number of composting facilities currently operate in the Los Angeles region. This is significant because there are not enough adequate facilities in place should the County transition away from single-use plastics to non-plastic materials/products. A more thorough explanation of compostable alternatives is further discussed in Section VII.

Materials in the Los Angeles County Waste Stream

It is important to understand the types and quantities of waste products in order to better assess the County's waste management practices. Waste distribution data is limited as 1) individual MRFs do not make their waste data publicly available for proprietary reasons, and 2) there is no accessible data on street-sweeping litter recovery in Los Angeles County. However, the Department of Resources Recycling and Recovery (CalRecycle) — the state agency overseeing waste management — does a county-level waste characterization in the form of residential and commercial streams by material type, the most recent being from 2014.[53]

In Los Angeles County, organics (45%), paper (19%), inert materials such as concrete (12%), plastics (10%), and metals (3%) make up the top five waste materials by tonnage produced by residences.[54] This includes both single-use and multifamily units. From the commercial waste stream, the top five materials are organics (36.8%), paper (30.3%), metal (9.4%), plastic (9.2%), and inert materials (9.1%).[55] While these figures may look different if considered by item count or volume, waste classification is primarily done by mass, and no other type of data is currently available. While MRFs receive all of these materials, plastics are among the most difficult to process and sell to market. According to various MRFs interviewed, this is because contamination is common in plastic materials and there are technological challenges to correctly sort different types of plastics. In addition, plastic materials are lightweight and can escape during transportation.

50 County of Los Angeles Department of Public Health (n.d.). Solid Waste Management Program Facilities. Retrieved from http://publichealth.lacounty.gov/eh/EP/solid_waste/facilitieslandfill.htm?func=1&Landfill=landfill

51 County of Los Angeles Department of Public Health (n.d.). Landfills. Retrieved from http://publichealth.lacounty.gov/eh/AreasofInterest/landfill.htm

52 Los Angeles County Department of Public Works (2017). Countywide Integrated Waste Management Plan 2017 Annual Report. Retrieved from https://pw.lacounty.gov/epd/swims/ShowDoc.aspx?id=11230&hp=yes&type=PDF

53 CalRecycle (2014). Solid Waste Characterizations Home. Retrieved from https://www2.calrecycle.ca.gov/WasteCharacterization/

54 CalRecycle (2014). Residential Waste Stream by Material Type. Retrieved from https://www2.calrecycle.ca.gov/WasteCharacterization/ResidentialStreams?lg=1019&cy=19

55 CalRecycle (2014). Business Group Waste Stream by Material Type. Retrieved from https://www2.calrecycle.ca.gov/WasteCharacterization/MaterialTypeStreams?lg=1019&cy=19

While plastics make up a smaller portion of the waste stream in terms of mass, they are disproportionately represented in the litter stream by item count and can ultimately make their way to the streets, beaches, and oceans as discussed in the previous section on impacts. Therefore, source reduction would lessen the detrimental effects plastics pose to the County both as waste and as litter. Furthermore, recent policies and regulation have made it even more difficult to manage the immense amount of waste, especially plastics in the waste stream.

How Recent Policy Has Upturned the Waste Industry

Traditionally, other countries have borne the brunt of solid waste from the United States. Prior to 2018, China was the preeminent market for waste exports, which relieved some of the waste burden for domestic municipalities but fostered a reliance on these external markets.[56] However, the implementation of China's "National Sword" policy in early 2018 significantly disrupted the market for plastic waste around the world. The policy imposed demanding restrictions on imported recyclable material and took effect immediately, giving the industry little time to sufficiently prepare. The new restrictions require the contamination level of recycled materials to be less than 0.5%.[57] This disruption has rippled throughout the global recycling markets and led to a sizable increase in waste material being kept in the United States after recovery by MRFs.

In the case of China's new restrictions, managing paper and plastic waste has become the most problematic. For example, one large facility in Los Angeles County noted that prior to the new restrictions, 98% of its paper went to China, but currently it exports only about 1%. This has had a significant economic impact, as the materials still need to be processed even if they are not sold. In some facilities, there is no longer a market for certain plastic materials, which results in their disposal at a landfill. All of the MRFs that were interviewed attested to the drastic change in market conditions that resulted from China's new policy. Not only does China no longer accept many materials, but other countries and facilities that purchase recovered materials have also implemented stricter contamination thresholds. China essentially strengthened quality control for all facilities. However, the MRFs also noted that contamination, infrastructure, and waste overabundance were already issues in the U.S. — the situation in China just highlighted and exacerbated them.

[56] Milman, Oliver. "'Moment of reckoning': US cities burn recyclables after China bans imports." *The Guardian*. February 21, 2019. Retrieved December 10, 2019, from https://www.theguardian.com/cities/2019/feb/21/philadelphia-covanta-incinerator-recyclables-china-ban-imports

[57] Resource Recycling, Inc. "China envisions years of 'National Swords.'" 2017. Retrieved from https://resource-recycling.com/plastics/2017/12/06/china-envisions-years-national-swords/

IV. the technical aspects of plastics

In order to understand the target of potential single-use plastics regulation in the County, it is crucial to take a detailed look into the different classifications and specific resin types that make up the more general plastics category. Traditional plastics are both inexpensive to make and durable to use, with a diversity of polymers that provide for a range of potential uses. These plastics' versatility and resistance to degradation can make them advantageous in food service ware applications.[58] These same resilient properties, however, consequently allow for plastic to persist in the environment, making complete decomposition nearly impossible.

We examine the different plastic resin types in this section, with an introduction to the general classifications of plastics including raw materials and subsequent additives. We then present the most common plastics more specifically by resin identification code, with listed properties, appearance traits and uses for each. This section concludes with a mention of recyclability challenges for these plastic resins, further analyzed in Section V.

Key Findings:

- Plastics are either identified as thermoplastics (able to be reheated and reshaped multiple times) or thermosets (limited to one permanent solid state). The most common types of plastic resins produced are thermoplastics.
- Their durability and versatility make traditional petroleum-based plastics suitable for a range of end-market uses and thus beneficial as single-use food service ware materials.
- For consumer and industry purposes, plastics are identified by resin identification codes (RICs) most often imprinted on the bottom of the product. These codes do not indicate recyclability — they instead serve as efficient sorting tools.
- None of the regularly used plastics (Codes 1-6) are biodegradable.[59]

Different Types of Plastics and Subsequent Impacts

Plastics are grouped into two general classifications: thermoplastics and thermosets. The former encompasses the majority of plastic products because of its design versatility and recoverability. Thermoplastics become liquid as opposed to burning when heated and solidify when cooled. They can be reheated and reshaped multiple times without compromising chemical properties, making them ideal for general food packaging applications. In contrast, thermosets are unable to melt back to original form, even at extreme temperatures. They can be heated only once. Thermosets remain in a permanent solid state once set and are thus more commonly used for automobile and construction materials.[60]

Most plastics are made with feedstock derived from petroleum including ethylene and propylene, making them inexpensive to manufacture. Further processing

[58] Thompson, R.C., Moore, C.J., Saal, F.S. vom, & Swan, S.H. (2009). Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences.* Retrieved from https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2009.0053

[59] Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances,* 3(7). Retrieved from https://doi.org/10.1126/sciadv.1700782

[60] Marsh, K., & Bugusu, B. (2007). Food Packaging — Roles, Materials, and Environmental Issues. *Journal of Food Science,* 72(3), R39–R55. Retrieved from https://doi.org/10.1111/j.1750-3841.2007.00301.x

to a polymer resin typically requires the use of additives including plasticizers, stabilizers, dyes and chemicals in order to strengthen the material and improve performance.[61]

Resin identification codes imprinted on plastic products indicate the type of material they are made from. It is important to note that the RIC does not signify that it is recyclable or that it is derived from recycled materials.[62] Instead, the RIC system simply provides waste collectors and facilities throughout the recovery and recycling chains with a standardized sorting tool. The RIC system was developed by the Society of the Plastics Industry in 1988 and has since been recognized globally with the help of the American Society for Testing and Materials.[63]

There are seven identification codes used for varying thermoplastic resins. Each is represented as a number between 1 and 7 enclosed by a triangular symbol (see Table 1). There are six codes of commonly used resins: Polyethylene Terephthalate (PET or PETE, Code 1), High-Density Polyethylene (HDPE, Code 2), Polyvinyl Chloride (PVC, Code 3), Low-Density Polyethylene (LDPE, Code 4), Polypropylene (PP, Code 5), and Polystyrene (PS, Code 6). Code 7 (OTHER) is used for products made from either mixed resins or a resin type other than the first six. These resins vary widely in their technical properties, products they are commonly used for (discussed below) and in their recycling outcomes in Los Angeles County (indicated below, the reasons for which are discussed in Section V).

Plastic Resins by Resin Identification Code

1. **Polyethylene Terephthalate (PET or PETE, Code 1)**
   PET is one of the most regularly used plastics. PET is extremely strong and resistant to bacteria, in addition to being lightweight and easy to transport.[64] These properties make it particularly suitable for a variety of food service ware applications. Beverage bottles and food jars are commonly manufactured from PET, along with certain types of single-use food service ware including clamshells, containers, and cups. All MRFs in Los Angeles County — apart from operators focused on niche sectors (e.g., construction and demolition) — currently recycle PET beverage bottles and food jars.
2. **High-Density Polyethylene (HDPE, Code 2)**
   HDPE is also one of the most commonly used plastic types. Both the high- and low-density versions of polyethylene are inexpensive to make and easy to form.[65] HDPE is strong and durable, providing good resistance to chemicals and moisture. It can be made in natural form (clear) or colored, and is often used to manufacture bottles for milk, juice, detergents and shampoos, along with less robust products such as plastic grocery and retail bags. The HDPE recycling market is currently the healthiest among the various plastic resins, and is ubiquitously recovered by MRFs in the County.
3. **Polyvinyl Chloride (PVC, Code 3)**
   PVC is a strong and rigid plastic that can be softened and made more flexible with plasticizers, including phthalates.[66] Nonplasticized (rigid) PVC is commonly used for heavy construction applications because of its stiff and noncorrosive properties.[67] Plasticized (flexible) PVC film is often used to create plastic medical, cosmetics and device packaging. Plastic cling wrap was previously a popular byproduct, but safety concerns over the use of phthalates in food packaging have resulted in a rise in PVC plastic wrap alternatives including LDPE.[68] Recycling of both

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[61] Thompson, R.C., Moore, C.J., Saal, F.S. vom, & Swan, S.H. (2009). Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences.* Retrieved from https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2009.0053

[62] Plastic Resins. (n.d.). Retrieved from https://www.calrecycle.ca.gov/plastics/resins

[63] Standard Practice for Coding Plastic Manufactured Articles for Resin Identification. (n.d.). ASTM International. Retrieved from https://www.astm.org/COMMIT/d7611.pdf

[64] Plastic Resins. (n.d.). Retrieved from https://www.calrecycle.ca.gov/plastics/resins

[65] Marsh, K., & Bugusu, B. (2007). Food Packaging — Roles, Materials, and Environmental Issues. Journal of Food Science, 72(3), R39–R55. Retrieved from https://doi.org/10.1111/j.1750-3841.2007.00301.x

[66] Plastic Resins. (n.d.). Retrieved from https://www.calrecycle.ca.gov/plastics/resins

[67] Ibid.

[68] Marsh, K., & Bugusu, B. (2007). Food Packaging — Roles, Materials, and Environmental Issues. *Journal of Food Science,* 72(3), R39–R55. Retrieved from https://doi.org/10.1111/j.1750-3841.2007.00301.x

forms is generally limited in Los Angeles County because they are difficult to identify and isolate in sorting processes, given the wide variety of products for which they are used.

4. **Low-Density Polyethylene (LDPE, Code 4)**
   LDPE is flexible and resistant to moisture, chemicals, and force.[69] Its lower density (compared to HDPE) and soft texture make it popular to use for nonfood service ware applications including plastic film and packaging (e.g., bags for trash, dry cleaning, newspapers, and produce). It is also used as an alternative to PVC plastic cling wraps. Rigid LDPE is used to make lids, caps, and toy products. There is currently no healthy market for recycled LDPE, and as such, it is not recycled in Los Angeles County.

5. **Polypropylene (PP, Code 5)**
   PP is extremely versatile and heat resistant. Its high melting point allows it to work well for use in food containers that are microwave and dishwasher safe, while also being a popular resin to make yogurt, ice cream, and pharmaceutical containers in addition to straws.[70] Its stiffness and moisture barriers allow it to be used for many appliances and automotive parts. PP can also be made into a fiber, often used for carpeting. Economically viable recycling of PP requires optical sorting equipment under current market conditions, and some facilities with this equipment currently recover PP in Los Angeles County. However, MRFs using only manual sorting methods have generally been unable to recover PP products.

6. **Polystyrene (PS, Code 6)**
   PS is naturally hard and brittle with a relatively low resistance to heat. It is inexpensive to produce and can be made into a solid or foam. Solid PS is often used to make disposable cutlery and smoke detector cases. Expanded polystyrene (EPS) white foam is conversely extremely lightweight and predominantly made of air. EPS is often, but erroneously, called "Styrofoam." However, Styrofoam is a particular brand of *extruded* polystyrene (XPS), a fundamentally different product.[71]

   EPS is used for food packaging (e.g., clamshells, cups, plates, and trays) as well as for protective packaging (e.g., egg cartons, coolers, cushioning, and building materials) because of its thermal insulation and impact protection. Its cheap nature lends itself to single-use disposal products, yet PS/EPS waste is especially difficult to transport and sort due to its weight. Its low density also makes it difficult for facilities to recover a mass of PS/EPS that is sufficient for recycling in an economically viable manner. PS recycling is thus generally inefficient and not practiced in Los Angeles County, and most PS/EPS goods — including food service ware — are either landfilled or littered.

7. **OTHER or Mixed Plastics (Code 7)**
   Plastics made of more than one resin or those that do not fit the previous categories are deemed OTHER. This category includes acrylic and nylon polymers. Code 7 products are not typically recyclable in Los Angeles County; however, bio-based and biodegradable alternatives to traditional plastics, such as polylactic acid, fall within this category and may have better recovery potential depending on available options for disposal (e.g., composting)

[69] Ibid.
[70] Ibid.
[71] Kingspan Insulation Middle East (2017). What is the difference between XPS and EPS? *Kingspan Group*. Retrieved January 6, 2020, from https://www.kingspan.com/meati/en-in/product-groups/insulation/knowledge-base/articles/general/what-is-the-difference-between-xps-and-eps.

Table 1: Plastic Resins by Resin Identification Code (RIC)

RIC	RESIN TYPE	PROPERTIES	USES	RECYCLED IN LA COUNTY
1 PET	Polyethylene Terephtalate	Lightweight; strong; resistant to bacteria; can be clear or color-matched	Water bottles; soda bottles; jars for spreads/jams; clamshells	Yes — bottles and jars only
2 HDPE	High-Density Polyethylene	Inexpensive; easy to form; strong; durable; resistant to chemicals and moisture; permeable to gas	Milk bottles; juice bottles; detergent/shampoo bottles; plastic grocery and retail bags	Yes
3 PVC	Polyvinyl Chloride	(Rigid) PVC: strong; stiff; noncorrosive (Flexible) PVC: softened with plasticizers	(Rigid) PVC: construction applications (Flexible) PVC: cling wrap; medical packaging; cosmetics packaging	No
4 LDPE	Low-Density Polyethylene	Flexible; soft; moisture-resistant; chemical-resistant	Plastic film; trash bags; dry cleaning bags; produce bags (Rigid) LDPE: lids; caps; toy products	No
5 PP	Polypropylene	Heat- and moisture-resistant; stiff	Yogurt containers; ice cream containers; microwavable food containers; automotive parts; carpeting	No — optical sorting-equipped facilities only
6 PS	Polystyrene	(PS): hard; brittle; low heat resistance; inexpensive (EPS): lightweight; thermal insulation; impact protection	(PS): disposable cutlery; smoke detector cases (EPS): clamshells; cups; plates; trays; egg cartons; coolers; cushioning	No
7 OTHER	Other	Mixed resins: acrylic, nylon; bioplastics (PLA)	Bottles; multilayer packaging	No

Major Considerations Regarding Plastics Recovery

Compared to glass or metals, plastics require more thorough sorting to be recycled, as each resin type varies by property and heat resistance. Plastics sorting is especially challenging because many plastic products are small and lightweight. Despite most plastics being technically recyclable, the fate of any given product depends heavily on market conditions and infrastructure.

v. recyclability of plastics

The recyclability of plastics is a central element in considering options to reduce generation and litter of plastic waste. Recycling reduces the overall environmental impact of plastic usage and reduces the burden of plastic waste on solid waste disposal systems. This waste must be hauled and processed by waste management operators and facilities, occupies limited landfill space, and can, in some cases, contaminate and degrade the value of other recyclable materials.

However, contrary to what may be a common perception, not all plastics are recycled. It is important to note that, while it is technically possible to recycle most plastics, there are many types for which it does not make economic sense to do so. The actual recyclability of any given plastic product depends on the type of plastic, market conditions, and other factors like contamination. Furthermore, there are fundamental aspects of the recycling process — such as the degradation in material quality that occurs — that limit the extent to which it can assist in addressing the problem of plastic waste.

In this section we first discuss the basic processes through which recycling works and why these processes cannot be used in isolation to address the issue of plastic waste. This is followed by an overview of how MRFs process and recover plastics for recycling. We then identify the key categories of plastics that are commonly recycled in Los Angeles County and those that are not, with additional discussion of certain types of products — including single-use plastic food service ware — that are especially problematic, along with a brief discussion of recycling market conditions.

Key Findings:

- Only HDPE (Code 2) products like milk jugs and detergent bottles and PET (Code 1) bottles (such as those used for beverages) and jars are currently commonly recycled in Los Angeles County.
- Polypropylene (Code 5) plastic is recovered effectively only in facilities with certain types of equipment, and plastics with codes 3, 4, 6, and 7 are generally landfilled.
- Single-use plastic food service ware, among other items, is especially challenging for MRFs to process and recover for recycling. Due to these challenges, single-use plastic food service ware is generally not recycled in the County.
- The limitations of recycling make it insufficient to be the sole means of addressing the impacts of plastic production and waste.

The Fundamentals of Plastic Recycling

Even under optimal circumstances, the current common process of recycling plastic resins is imperfect. Plastic items recovered at a MRF or equivalent facility are typically mechanically broken down via shredding or grinding, then subjected to high temperatures to melt the plastic into pellets.[72] These pellets can then be sold to product manufacturers.

However, this process degrades the quality of recycled plastic compared to virgin material. The polymers of plastic resins are affected negatively both during the normal lifetime of the original product and by the recycling process.[73] Additionally, the incidence of impure inputs and contamination that often occurs can produce mixed-resin products that are less valuable and versatile than pure or virgin material. In cases where products are manufactured from multiple material types that cannot

[72] Tullo, Alexander H (2019). Plastic has a problem; is chemical recycling the solution? Chemical & Engineering News 97 (39). Retrieved December 10, 2019, from https://cen.acs.org/environment/recycling/Plastic-problem-chemical-recycling-solution/97/i39

[73] La Mantia, Francesco Paolo (2004). Polymer Mechanical Recycling: Downcycling or Upcycling? Progress in Rubber, Plastics and Recycling Technology 20(1). https://doi.org/10.1177%2F147776060402000102.

be readily separated, this outcome is more-or-less inevitable. This phenomenon, whereby recycling produces a less desirable product than the inputted material, is termed "downcycling."[74]

Downcycling has significant ramifications for the role of recycling in reducing plastic waste and its associated impacts. First, it imposes a terminal point on the life of any given plastic product, past which further recycling of the resin will produce recovered material so degraded that it is essentially valueless. Consequently, the current model of recycling likely does not displace production of new plastic on a one-to-one basis, even though many assessments of recycling benefits have assumed this condition.[75] This concept is illustrated by the findings of a 2016 World Economic Forum report, noting that despite a global 14% collection rate of plastic packaging for recycling, only 5% of the material value was retained post-processing.[76] It is estimated that, between 1950 and 2015, only 0.9% of plastics produced has been recycled more than once, and doing so may not be an unequivocal benefit given the inputs of the process combined with the diminishing returns of the product.[77]

Second, recycled material merely delays production of virgin material from fossil fuel precursors until a later date.[78] This means that recycling alone, using current common methods, is incapable of eliminating the impacts — such as greenhouse gas emissions — of plastic production, even in the unlikely event that recycling rates reached 100%.

However, in comparison to other historically common disposal options such as landfilling and incineration, recycling has consistently been the least harmful option from an environmental standpoint.[79] Therefore, while not a comprehensive solution to the impacts of plastic waste and production, increased recycling of plastic in Los Angeles County will likely be beneficial in the short to mid term. Without incorporation of as-yet unproven technologies and strategies that allow for one-to-one displacement of virgin with recycled material, though, plastic recycling in the long term will depend on the continued production of new material from fossil fuel stocks.

Most notable among these approaches are chemical recycling processes and related technologies.[80] These offer a fundamentally different model of recycling plastic, with potentially transformative impacts on the plastic and recycling industries. Under this approach, the monomer building blocks of plastics are dissolved, allowing them to be either reassembled — with no decrease in product quality, theoretically — or converted to a combustible fuel. The former is referred to as monomer recycling, while the latter procedure includes processes such as gasification and pyrolysis.[81] However, these approaches are in their nascent stages and have not been implemented in a commercially viable, scaled facility in the United States. Development and expansion to the necessary extent would require massive monetary investment, to the tune of billions of dollars.[82] Furthermore, fuel-producing procedures like pyrolysis perpetuate the practice of combusting fossil fuels for energy, albeit with the insertion of an extra stage in the life of the product.

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74 Geyer, Roland, Brandon Kuczenski, Trevor Zink, Ashley Henderson (2015). Common Misconceptions about Recycling. Journal of Industrial Ecology 20(5), 1010-1017. https://doi.org/10.1111/jiec.12355.

75 Ibid.

76 World Economic Forum (2016). The New Plastics Economy: Rethinking the future of plastics. Retrieved December 10, 2019, from http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf

77 Geyer, Roland, Jenna R. Jambeck, Kara Lavender Law (2017). Production, use, and fate of all plastics ever made. ScienceAdvances 3(7). DOI: 10.1126/sciadv.1700782.

78 Geyer, Roland, Brandon Kuczenski, Trevor Zink, Ashley Henderson (2015). Common Misconceptions about Recycling. Journal of Industrial Ecology 20(5), 1010-1017. https://doi.org/10.1111/jiec.12355.

79 Bernardo, C.A., Carla L. Simoes, Ligia M. Costa Pinto (2016). Environmental and economic life cycle analysis of plastic waste management options. A review. *AIP Conference Proceedings* 1779(140001). https://doi.org/10.1063/1.4965581.

80 Chaudhur, Saabira (2019). Plastic Backlash Leads to Bets on Old Recycling Technology. *The Wall Street Journal*. Retrieved December 10, 2019, from https://www.wsj.com/articles/companies-dust-off-old-technology-in-search-of-high-quality-recycled-plastic-11575801000

81 Hundertmark, Thomas, Mirjam Mayer, Chris McNally, Theo Jan Simons, Christof Witte (2018). How plastics waste recycling could transform the chemical industry. *McKinsey & Company*. Retrieved December 10, 2019, from https://www.mckinsey.com/industries/chemicals/our-insights/how-plastics-waste-recycling-could-transform-the-chemical-industry

82 Ibid.

How Materials Recovery Facilities Recover Recyclable Plastic

MRFs recover recyclable material in a manner similar to an assembly line. The raw waste materials are spread out on a conveyor. As the material makes its way through the facility, each stage attempts to separate out particular types of valuable material. These materials include paper and cardboard, ferrous metals (e.g., tin cans), nonferrous metals (e.g., aluminum cans), plastic, and glass.

Isolation of recyclable plastic is done via several mechanisms:

A. ***Optical Sorters*** (see Figure 1). The most effective method currently in use, optical sorters identify types of plastic based on how light reflects off a given item. The device scans passing items for a match to the reflectivity profile with which they are programmed. Waste proceeds beneath the scanner on a conveyor belt and plastics that the scanner identifies as desirable are directed to a separate sorting line with blasts from air jets. Other items, including plastics that do not match the scanner's profile, pass through.
   Optical sorters have the advantage of achieving high recovery rates while maintaining high throughput volumes and minimizing contamination. However, there are drawbacks. The equipment is expensive, with an individual unit costing nearly $650,000 in equipment, transport, and installation, in addition to lost operations time. As a result, the equipment is not yet ubiquitous at MRFs processing waste from Los Angeles County. While six of seven MRF operators interviewed for this report indicated the presence of optical sorting equipment at some of their facilities, five indicated that they operate some facilities that do not have the technology.

Despite their advantages, optical sorters are imperfect. The reflective scanning mechanism cannot recognize black plastic items, nor can it identify plastic products that are contaminated with food or another residue. Lightweight plastic items may also be problematic, as they are not easily redirected by the air jet used to separate valuable material. Such problems illustrate the need for better alignment between product specifications and options for end-of-life disposal.

Figure 1: An optical sorter at work.

Items on the conveyor are carried under the optical scanners, which identify desirable materials to be redirected with targeted air jets to a different destination. Other items fall to the next stage of the material recovery facility system.

Figure 2: An example of a robotic sorting system used in material recovery facilities.

Essentially a cross between optical sorters and human personnel, they employ programmable scanners to identify items on a conveyor and mechanically separating them.

Source: Bulk Handling Systems. Max-AI https://www.max-ai.com/

B. ***Robotic sorters*** (see Figure 2). Robotic sorters operate essentially as a cross between optical sorters and human personnel, using programmable scanners to identify items on a conveyor and mechanically separating them with an arm or similar device. Robotic automation allows for significantly higher "picks per minute" (items separated from a conveyor in a minute) than a human worker, helping to improve recovery rate of recyclable materials.

Robotic sorters are far less expensive than optical sorting equipment, with costs reported by one MRF operator ranging from $200,000 to $250,000. They can also be more easily integrated into existing facilities than optical sorters. Despite this, the technology is not ubiquitous. Four of seven MRF operators interviewed indicated that their facilities already utilized or were considering implementing robotic sorting.

A major drawback is that robotic sorters do not achieve nearly the same level of performance as optical sorters: The latter can perform approximately 600 picks per minute compared to the 60 by the robots, a factor of 10 difference.[83] Based on conversations with industry experts, future market conditions will likely necessitate widespread adoption of optical sorters, though robotics could serve as an interim improvement and as a backup to optical technology.

C. ***Manual separation.*** Recyclable plastic items can be removed from conveyors by human personnel identifying them by sight. Most, if not all, MRFs continue to use human personnel for sorting in some capacity. Even in facilities equipped with optical and robotic sorters, human workers continue to serve as a backstop, catching materials that manage to pass through the automated systems. However, sorting by hand is slower, less efficient, and less reliable than automated methods. Repetitive motions can make workers prone to workplace injury and, as in many industries, automated methods are generally more consistent in terms of work schedules while being less expensive.

What Is Recyclable? Plastics and Product Categories

Based on conversations with operators and experts in the Los Angeles area waste industry, two of the major plastic resin types are currently viable for recycling. However, these plastics vary in their recyclability depending on the type of product they are used to make.

A. ***High-Density Polyethylene (HDPE, Code 2):*** HDPE is currently the most valuable plastic resin type for recovery in the Los Angeles area. All MRF operators interviewed (eight of eight) currently recover HDPE, separating it by "natural" — the semitransparent

[83] Redling, Adam (2018). Sorting it all out: Considerations for integrating optical sorters and robotics in a MRF. *Recycling Today.* Retrieved November 30, 2019, from https://www.recyclingtoday.com/article/considerations-for-integrating-optical-sorters-and-robotics-in-a-mrf

form — and "colored" — the opaque variant that comes in a multitude of colors. While these two forms of HDPE have separate pricing markets, both are quite robust, with recovered material fetching a significantly higher price than other plastic types.

B. ***Polyethylene terephthalate (PET or PETE, Code 1):*** PET is currently recovered by most MRFs serving Los Angeles County; seven of eight indicated they currently recovery the material, the exception being a MRF that primarily processes demolition and construction material, and as such does not receive significant amounts of PET plastic. However, two significant limitations make PET a less attractive option for recovery, generally, than HDPE. First, based on conversation with industry experts, the only category of PET plastic products that are consistently recycled are beverage bottles and jars. While such products are consumed and recovered in significant numbers, usage of other categories of PET products, including food service ware, is not beneficial if recyclability is a priority. Second, the market price for recovered PET is not as high as that for HDPE, resulting in slimmer profitability margins for operators.

Polypropylene (PP, Code 5) merits special discussion. Currently, PP is not commonly recovered by facilities in the Los Angeles area; only one MRF operator interviewed recovers the material, and at only one facility. PP can be recovered and sold at a profit at this facility because of a significant investment in optical sorting technology. As more facilities integrate optical sorters into their recovery processes PP may become more viable for widespread recovery, but it is not generally recycled under current conditions. Government support for such capital investment may be helpful in speeding the adoption of this technology, enhancing the degree to which PP is recovered.

Outside of these categories, other plastics — regardless of the type of product — are not recovered and are sent to landfills. This includes PVC (Code 3), LDPE (Code 4), PS and EPS (Code 6), and OTHER or mixed plastics (Code 7). There are rare exceptions in niche cases that are not representative of conditions in the broader waste landscape. One MRF interviewed continues to bale mixed plastics (Codes 3-7) at a facility outside the Los Angeles region, but these products are a small component of the waste stream and are almost valueless for post-recovery sale. This facility continues to recover these materials essentially because they have the capacity to do so and it represents an environmental benefit, despite being neutral in fiscal terms.

Certain types or categories of plastic products are especially difficult to recover and recycle. These products are unlikely to be recyclable in the foreseeable future and in some cases can be actively detrimental to the recycling of other materials. Included in this category are expanded polystyrene, plastic food service ware and accessories, small plastic pieces, and items that are harmful or dangerous to MRF personnel and equipment.

a. ***Expanded polystyrene (EPS):*** EPS is particularly difficult to recycle and can be actively detrimental to MRF operations. The lightweight, low-mass nature of EPS makes it challenging for facility equipment to consistently direct materials through the conveyors and machinery used in the recovery process. Additionally, fragmentation of EPS blocks and products can produce large numbers of plastic particles that pervade facilities and contaminate other recoverable materials.
   In the context of food service ware, EPS tends to absorb more grease and oil than other commonly used plastics, making it more difficult to recycle and degrading its already-low value.

b. ***Plastic food service ware and accessories:*** Disposable plastic food service ware — which may be manufactured from several different resins, including PET, PP, and PS or EPS — is challenging to recover due to the issues of food residue and small size. Only one of the eight MRF operators interviewed indicated that it currently recovers and bales plastic food service ware on a routine basis at any locations, and this facility is not part of the Los Angeles County waste landscape. A notable component of this operation is a concerted public education campaign to encourage residents to rinse food service ware before placing it in the recycle bin, a program with no current analog in the County. Additionally, such practices are infeasible in instances when customers do not have access to the facilities necessary to do so (e.g., a public beach). No Los Angeles-based MRF indicated that it recovers and recycles plastic food service ware.

Even when relatively clean, the size and construction of plastic food service ware makes recovery difficult. Small accessory items, such as straws and utensils, are hard to process and bale. Larger items like food clamshell containers can still be difficult to recover using optical sorters, as the air jets used to separate items can cause lightweight items to miss their intended destination.

In addition to the issue of recovering plastic food service ware, food waste and residue can contaminate other products in the recycling stream, reducing their value or making them unrecoverable. This is especially problematic when food waste soils fiber-based material like paper or cardboard.

Based on conversations with industry experts, there is potential for plastic food service ware beverage containers, such as PET cups used for cold beverages, to be recovered. Contamination is a minimal issue with this category of items compared to other types of food service ware. While no Los Angeles area MRF interviewed indicated that they make a concerted effort to recover such items, it seems likely that optical sorting technology could easily identify and separate these products.

c. ***Small plastic pieces:*** Small pieces of plastic — less than a few inches long — are challenging to recover and bale in a manner that is efficient enough for it to be sustainable by a MRF. Such items can easily become scattered in unintended ways during the sorting process. Each piece also represents a small mass of material, and thus it is more difficult to achieve the volumes necessary to bale and sell the recovered plastic. These items may be more viable for recovery in a secondary MRF processing residual inputs from multiple MRFs. The only facility operating under this model is the Los Angeles location operated by Titus MRF Services.

   Common types of items that fall into this category include aforementioned food service ware accessories like straws and utensils, pieces of packaging from unpacked consumer goods, bottle caps, and small consumer items (e.g., plastic toys, cotton swabs).

d. ***Harmful or dangerous items:*** Several MRF o perators identified commonly encountered items that can be harmful to their processes by jamming or damaging equipment, and which can potentially cause workplace injuries to facility personnel. These include some items containing plastic such as package bindings or webbing, garden hoses, and pet food bags. Generally, tough plastic products that can become wound around machinery are hazardous to MRF operations.

Market Factors for Recovered Plastic

China's National Sword regulation has drastically lowered the acceptable contamination threshold for baled recovered material that most MRFs strive to achieve while simultaneously cratering the market for some plastic materials, most notably mixed plastics (bales of material with Codes 3-7) and product categories with high contamination rates like single-use food service ware. However, the change represents an environmental benefit: Several interviewed operators characterized National Sword not as creating a new problem for recycling, but merely making extant issues harder to ignore. The policy forced the domestic waste industry to confront the fact that significant quantities of "recyclable" material shipped across the Pacific Ocean were, in fact, being incinerated, littered, or landfilled.

The rippling effects of National Sword have imposed new fiscal burdens on operators, customers, and municipal governments in the Los Angeles region and across the United States. The primary driving force behind these disruptions is the decreases in value for several categories of items previously considered recyclable, such as mixed plastics (Codes 3-7), paper, and cardboard.[84] In some cases, values for certain goods have fallen so precipitously that operators are paying landfills or other destinations to have an output option for the material,

[84] Wisckol, Martin (2019). Your recyclables are going to the dump and here's why. Orange County Register. Retrieved January 7, 2020 from https://www.ocregister.com/2019/05/17/your-recyclables-are-going-to-the-dump-heres-why/

whereas previously these items would have been a source of profit.[85] This has led many operators in the waste industry — including haulers, MRFs, and recycling centers — to experience a sizable drop in revenue, putting them in dire financial straits.

Consequent outcomes have been varied. Many facilities, including several recycling centers and MRFs in Los Angeles County, have closed since 2018 because of operational losses.[86] Other locations in California remain open but face operational losses — which can exceed millions of dollars annually — that threaten their longevity.[87] In many other instances, operators have cut back on services or raised prices through newly negotiated municipal contracts or weekly rates, imposing additional costs onto local governments and customers.[88] The economic impact on these parties is compounded by falling revenue from recycling programs. An illustrative example is the City of San Diego, which expected to receive approximately $600,000 in revenue from its recycling contractors for the 2019 fiscal year compared to $4 million in 2017.[89] Thus, while firm figures have been difficult to identify for Los Angeles County or the City of Los Angeles, it is likely that they and ratepayers are bearing millions of dollars in additional costs due to changes in the recycling market since 2018.

For MRFs in the Los Angeles region, international markets currently play a significantly smaller role with regard to selling recovered plastic compared to pre-National Sword regulation. All six applicable MRFs interviewed indicated that their primary market for major resin categories — especially PET (Code 1) and HDPE (Code 2) — were now within California. The market for these resins, especially PET, is strong in the Los Angeles region specifically. Several MRFs also indicated that Alabama-based KW Plastics is a high-profile destination, particularly for resins other than PET and HDPE (i.e., Polypropylene, Code 5).

Four MRFs indicated that small markets for particular resins continue to exist overseas in Southeast Asia, including Indonesia and Vietnam. However, this is predominantly polypropylene (Code 5) and, at the one facility interviewed that still bales it, mixed plastics (Codes 3-7), as there are robust domestic markets for PET (Code 1) and HDPE (Code 2).

More generally, there is some caution amongst MRF operators about how market conditions may continue to fluctuate and the impacts this may have on their business. Currently, the only plastic resins that can be said with confidence to have healthy, stable markets are PET and HDPE. The market for PP, according to one operator, is teetering on the edge of viability. Besides niche cases, as aforementioned, other categories of plastic are not generally economically viable to recover in Los Angeles County.

An important element of the National Sword regulation is that it demonstrated to operators that market conditions for recovered plastic can change unpredictably, quickly, and drastically. One operator expressed concern that companies may endanger themselves by investing heavily in hardware and facilities to recover certain materials — such as plastics like PET with a current healthy market — only for conditions to change again and leave them in an untenable position. While cliché, this underscores the importance of certainty to businesses, and should be considered in any future policy decisions made by the County.

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85 McDaniel, Piper (2019). As California's recycling industry struggles, companies and consumers are forced to adapt. Los Angeles Times. Retrieved January 7, 2020 from https://www.latimes.com/environment/story/2019-08-13/california-recycling-industry-plastics-china

86 Ibid.

87 Schussler, Anna (2018). Where does it go? The Daily Journal. Retrieved January 8, 2020, from https://www.smdailyjournal.com/news/local/where-does-it-go/article_ca096e96-b717-11e8-909a-5bd7c61b91ae.html

88 Mahoney, Erika (2019). Global Recycling Changes Trigger Potential Garbage Rate Increase In Monterey. 90.3 KAZU. Retrieved January 8, 2020, from https://www.kazu.org/post/global-recycling-changes-trigger-potential-garbage-rate-increase-monterey#stream/0; Geha, Joseph (2019). Union City recycling rates increase as city leaders, recycler debate costs. East Bay Times. Retrieved January 8, 2020, from https://www.eastbaytimes.com/2019/08/30/union-city-recycling-rates-increase-as-city-leaders-recycler-debate-costs/

89 Smith, Joshua Emerson (2019). Cities scrambling to clean up curbside recycling in wake of China ban. The San Diego Union-Tribune. Retrieved January 8, 2020, from https://www.sandiegouniontribune.com/news/environment/sd-me-recycling-revenues-fall-20190317-story.html

VI. analysis of plastic alternatives

Alternatives to plastic packaging have proliferated in recent years: Options for compostable packaging have expanded, particularly in the field of disposable food service ware, and several cities in California have enacted policies designed to increase usage of reusable items by food vendors and their customers. However, it cannot be assumed that any alternative will have lower impacts and better disposal options than plastic. It is therefore important for the County to evaluate the pros and cons of these options as it considers policy options to reduce plastic waste generation and litter.

In this section we focus on the two main categories of alternatives to single-use plastic food service ware: reusable ware and compostable disposables. With respect to the former we discuss how lifetime environmental impacts compare to plastics, the economic ramifications of increased adoption, and some important considerations unique to a transition to reusables. For the latter, we discuss the nature of compostable and biodegradable materials, including some specific types, and perform a similar comparison of the lifetime impacts of these products to plastics when used for food service ware. We identify particular challenges related to the disposal of such items and review the economic ramifications of increased usage.

Key Findings:

- Utilizing reusable food service ware in place of disposable options has the greatest potential to reduce the negative impacts associated with plastic waste in Los Angeles County, among the alternatives available.
- Increased adoption of compostable items may be beneficial, but many factors complicate selection of appropriate alternatives within this product category.
- Available evidence indicates that threats to businesses and the economy overall posed by transitions to plastic alternatives are small, if any. Available evidence suggests that food vendors may benefit fiscally following adoption of reusable items and that reducing plastic waste will lower costs on operators, municipal governments, and ratepayers. However, specific quantifiable predictions in this area are difficult to make.

Reusable Alternatives

Based on available information, increased usage of reusable ware in the Los Angeles County food service sector would likely be an unequivocal net benefit. Potential avenues for such a transition include more consistent usage of reusable items at dine-in food service locations, increasing the frequency with which customers purchase beverages in reusable cups or travel mugs, and adopting models that allow for food and beverage to be placed in reusable containers.

Reusable ware avoids many potential pitfalls and challenges posed by the need for disposal. With regard to environmental impacts, the available research strongly favors reusable food service items having lower impacts than equivalent disposable items over the course of a product's lifetime. More so than alternative disposable items, however, increased adoption of reusables would in many cases require investment in new equipment and reworking everyday practices by businesses, in addition to raising potential issues regarding compliance with health code in the case of customer-owned reusable items.

Table 2: Relative Impacts of Plastic Food Service Ware and Alternative Usage

				IMPACTS			
ALTERNATIVE OR RESTRICTION	**EXAMPLE MATERIALS**	**USES**	**CHALLENGES**	**ENVIRONMENTAL**	**COST TO BUSINESSES (varies by product)**	**LITTER PREVENTION**	**WASTE PROCESSING COSTS (e.g., hauling rates, municipal contracts)**
Plastic	PET; polypropylene	All disposable food service ware	Recovery & recyclability	■	■	■	■
Bioplastic	PLA; PHA	Cold beverage cups/lids; hot beverage cup linings; clam-shells; straws	Limited heat resistance; end of life disposal	■	$-$$	■	■
Upon Request	N/A	Utensils, straws, condiments	None	*	$	$	$
100% Fiber- based	Molded pulp; bamboo; bagasse	Clamshells; utensils; plates/ bowls/trays;	Grease; durability; absorption; chemical coatings (e.g., PFAS); end of life disposal	**	$	$	$$
Reusables (Customer-owned)	Stainless steel; polypropylene	Travel mugs; to-go boxes	Health code; cultural norms	***	$	$$	$$$
Reusables (Vendor-owned)	Plastic; Ceramic; Metal	Dining ware	Capital investment (infrastructure, dishwashing equipment, items); operating procedures	***	**Short-term:** $$$ **Long-term:** $$	$	$$$

Interpreting impacts: ■ indicates status quo.
Environmental benefits (e.g., reduced ecological harm, lower emissions) of scenarios compared to status quo:
* marginal improvement; ** moderate improvement; *** major improvement.

Economic impacts (e.g., purchasing costs, operating costs, municipal expenditures): **red** = increased costs; **green** = reduced costs.
$** small change; **$$** moderate change; **$$$ major change.

Comparative Life Cycle Impacts of Reusables

Across most environmental impact categories, existing research shows a consensus that a reusable food service ware product — given reasonable assumptions about its lifetime uses — will have a smaller footprint than disposable options. The exact break-even point can vary somewhat among product types, depending on production inputs and rates of loss, theft, or breakage. Estimates may also vary based on the exact methods researchers use. The main (but not exhaustive) categories by which reusables and disposables have been historically compared are greenhouse gas emissions, energy inputs, water use, ecosystem impacts, and solid waste generation.

Even accounting for varying methodologies, reusable items result in lower lifetime impacts than disposables. In one of the most heavily studied comparisons — ceramic coffee cups versus disposable paper or polystyrene cups — estimates on lifetime uses for the former to outperform disposables range from as low as 18 (vs paper) or 70 (vs polystyrene) to a few hundred.[90] To put these numbers in context, lifetime uses of dishware in a food service setting can be in the thousands.[91] It is also worth

[90] Sheehan, Bill (2017). Greenhouse Gas Impacts of Disposable vs Reusable Foodservice Products. *Clean Water Action/Clean Water Fund*. Retrieved December 12, 2019 from https://www.cleanwateraction.org/sites/default/files/CA_ReTh_LitRvw_GHG_FINAL_0.pdf

[91] City of Portland Sustainability at Work (2019). Reusable Dishware (Why switch?). *The City of Portland Oregon Sustainability at Work*. Retrieved December 12, 2019, from https://www.portlandoregon.gov/sustainabilityatwork/article/507480

noting that, as a general trend, more recent studies in this area tend to find lower break-even points — that is, reusables seem to become more advantageous compared to disposables over time. It is likely that increases in the energy and water efficiency of dishwashing processes bear some responsibility for this trend, and that it will continue as decarbonization of the electricity grid continues.[92]

In the case of other reusable food service ware items — including water containers, food clamshells, travel mugs, and utensils — reusables continue to exhibit lower lifetime impacts than functionally similar disposable products. While life cycle analysis research on these items is less prevalent than studies comparing ceramic mugs and disposable cups, what data is available tends to show greater benefits and lower break-even points for reusables in these categories. Lifetime uses for these products may need to be as low as 10-50 (plates and bowls), 15-30 (clamshells), or two (flatware/utensils) to be preferable to their disposable counterparts.[93] Findings of reusable preferability hold for items that are commonly customer-owned, such as plastic or stainless steel travel mugs and to-go food boxes made from materials like polypropylene.

Perhaps the most impactful effect of replacing disposable food service ware with reusables is in the area of solid waste. Past assessments and case studies have found that transitioning to reusables from disposables in both the food service sector and other areas (e.g., drinking water) drastically reduces weight and volume of solid waste generated.[94] In a case study (albeit from the early 1990s) of hospital food service, replacing disposable items with reusable dishes reduced solid waste generation by 99%.[95]

Despite available research consistently favoring reusable food service ware items over disposables in terms of lifetime environmental impact, there are two important caveats:

A. ***Impact Categories:*** While reusables generally outperform disposables in lifetime energy inputs and greenhouse gas emissions, other categories can deliver mixed results depending on the specific product. For instance, an assessment of reusable coffee containers by CIRAIG found that, while still a better option overall, travel mug impacts were similarly severe or worse in the Quality of Ecosystems and Water Consumption categories.[96] In particular, water usage associated with cleaning practices is an important consideration, though one that can be ameliorated through increased efficiency. Negative impacts of reusable products can also be lessened by adopting those that use less material in their manufacturing process while maintaining durability.

B. ***Public Events:*** Some studies have found mixed results when comparing the impacts of reusables versus disposables in certain settings. The primary example is public events, where comparisons of different food service ware cup options have yielded inconclusive results on which is most desirable from an environmental impact standpoint.[97] Small-scale

[92] Woods, Laura and Bhavik R. Bakshi (2014). Reusable vs. disposable cups revisited: guidance in life cycle comparisons addressing scenario, model, and parameter uncertainties for the US consumer. *The International Journal of Life Cycle Assessment* 19, 931-940. doi:10.1007/s11367-013-0697-7. Retrieved December 12, 2019, from https://link.springer.com/article/10.1007/s11367-013-0697-7

[93] Broca, Mita. (2008). A comparative analysis of the environmental impacts of ceramic plates and biodegradable plates (made of corn starch) using Life Cycle Analysis. *Department of Natural Resources TERI University*. Retrieved from http://sustainability.tufts.edu/wp-content/uploads/LifeCycleAnalysisPlasticPlatevsCeramic.pdf; Copeland, Audrey M., Alison A. Ormsby, Andrea M. Willingham (2013). Assessment and Comparative Analysis of a Reusable Versus Disposable To-Go System. *Sustainability: The Journal of Record* 6(6). https://doi.org/10.1089/SUS.2013.9832; Sheehan, Bill (2017). Greenhouse Gas Impacts of Disposable vs Reusable Foodservice Products. *Clean Water Action/Clean Water Fund*. Retrieved December 12, 2019, from https://www.cleanwateraction.org/sites/default/files/CA_ReTh_LitRvw_GHG_FINAL_0.pdf

[94] Franklin Associates (2009). Life Cycle Assessment of Drinking Water Systems: Bottle Water, Tap Water, and Home/Office Delivery Water. *State of Oregon Department of Environmental Quality*. Retrieved December 12, 2019, from https://www.oregon.gov/deq/FilterDocs/wprLCycleAssessDW.pdf; Keoleian, Gregory A. and Dan Menerey (1992). Disposable Vs. Reusable Systems: Two Source Reduction Case Studies. *Journal of Environmental Systems* 20(4), 343-357. doi: 10.2190/P25E-HNAE-7G81-JAPY.

[95] Keoleian, Gregory A. and Dan Menerey (1992). Disposable Vs. Reusable Systems: Two Source Reduction Case Studies. Journal of Environmental Systems 20(4), 343-357. doi: 10.2190/P25E-HNAE-7G81-JAPY.

[96] CIRAIG & Recyc-Quebec (2014). Life cycle assessment (LCA) of reusable and single-use coffee cups. *CIRAIG and Recyc-Quebec*. Retrieved December 12, 2019, from https://www.recyc-quebec.gouv.qc.ca/sites/default/files/documents/acv-tasses-cafe-resume-english.pdf.

[97] Vercalsteren, An, Carolin Spirinckx, Theo Geerken (2010). "Life cycle assessment and eco-efficiency analysis of drinking cups used at public events." *The International Journal of Life Cycle Assessment* 15(2), 221-230. DOI: 10.1007/s11367-009-0143-z. Retrieved December 12, 2019, from https://www.infona.pl/resource/bwmeta1.element.springer-9824e24a-4a37-3060-aee1-fa8ce403d519

events appear to be more conducive to effective reusable usage, but large events are an area where conclusions on best options cannot be drawn at this time, due to inconclusive data.

Economic Ramifications of Increased Reusable Adoption

Using reusable ware in the food service sector in place of disposables represents a large shift for many food vendors, one which can change their cost burdens significantly. The exact outcomes for any given business vary depending on a number of factors, but there are consistent trends and trade-offs that have been found.

Adoption of reusables shifts a food vendor's expenditures toward larger, up-front, one-time costs.[98] These come as investments in both reusable items themselves and in the equipment to clean them, the total costs for which can be thousands of dollars or more, depending on the size of the business. In contrast, disposable items impose a lower initial, but constant, recurring cost.

Available studies suggest that a transition from disposables to reusables typically leads to significantly lower expenditures for food service ware while slightly increasing costs associated with equipment, utilities, and labor on a per-meal or per-customer basis.[99] Recent case studies in both the private food vendor and public institution sectors show that, over time, adoption of reusables tends to result in net savings for vendors.[100] These direct cost savings for businesses can total thousands of dollars per year, with the fiscal break-even point occurring within the first year of the transition.

Additionally, businesses that adopt reusables tend to hire more personnel for dishwashing tasks, leading to more jobs and their associated macroeconomic benefits.[101] The reduction in solid waste production also has economic benefits, though these are difficult to quantify.

Other Considerations for Implementation

Because reusable food service ware requires a fundamentally different usage model, there are certain key aspects where they differ from other alternatives with regard to implementation.

A. ***Health Code Concerns:*** California Assembly Bill-619 was signed into law in July 2019, laying out rudimentary guidelines for how food vendors can accommodate customers bringing personal reusable food and drink containers in a sanitary fashion. However, based on conversations with government health officials, there are still concerns regarding compliance with health code when it comes to customer-owned reusables. Businesses may need to change their procedures and/or even the physical layout of their food preparation and pickup areas if they wish to facilitate customer-owned reusables usage, discussed further in item D below.

B. ***Equipment and Space Constraints:*** It may be difficult for some food vendors to utilize reusables and/or install dishwashing equipment due to physical space limitations or other facility attributes. Should the County desire that these businesses adopt reusables it may wish to facilitate potential workarounds, such as centrally located dishwashing facilities shared by multiple vendors or mobile dishwashing services.

C. ***Alignment and Disposal Advantages:*** Based on all available evidence, adoption of reusable food service ware in place of disposables is an unequivocal net environmental benefit. Compared to other types of alternatives, reusables are well-aligned with the County's stated sustainability goals. Reusables also have a logistical advantage in that disposal options are not a major consideration, given the reductions in solid waste generation that accompany

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98 Ellis. "Disposables versus reusables in foodservice operations." 7 March 2018. *Foodesign The Food Service Design Agency*. Retrieved December 12, 2019, from https://foodesignassociates.com/disposables-vs-reusables-food-service/

99 Keoleian, Gregory A. and Dan Menerey (1992). Disposable Vs. Reusable Systems: Two Source Reduction Case Studies. *Journal of Environmental Systems* 20(4), 343-357. doi: 10.2190/P25E-HNAE-7G81-JAPY.

100 City of Portland Oregon Sustainability at Work (2019). Restaurant Case Study. *The City of Portland, Oregon Sustainability at Work*. Retrieved December 12, 2019, from https://www.portlandoregon.gov/sustainabilityatwork/article/507590; Cioci, Madalyn (2014). The Cost and Environmental Benefits of Using Reusable Food Ware in Schools. *Minnesota Pollution Control Agency*. Document number: p-p2s6-16. Retrieved December 12, 2019 from https://www.pca.state.mn.us/sites/default/files/p-p2s6-16.pdf

101 City of Portland Oregon Sustainability at Work (2019). Restaurant Case Study. *The City of Portland, Oregon Sustainability at Work*. Retrieved December 12, 2019, from https://www.portlandoregon.gov/sustainabilityatwork/article/507590

their adoption. This gives them an advantage over single-use food service ware alternatives, given the complexity of finding environmentally beneficial end-of-life options for these products in the Los Angeles waste landscape.

D. ***Takeout and Delivery Food Service Challenges:*** Utilizing reusable ware in the context of take-out food or delivery orders presents additional challenges that may or may not be insurmountable in the short term, depending on the given food vendor. In the former case, both customer- and vendor-owned reusables are potential options. However, each has major caveats. Allowing customer-owned reusables would require institution of new spaces and practices by businesses to maintain sanitation requirements, with commensurate increases in time and labor involved. Alternatively, businesses could provide customers with food on reusable ware (e.g., a plate or tray) from which customers transfer the food to their personal containers and then return the transfer item. However, for businesses that currently use disposable food service ware, this would still require investing in these transfer items and the capacity to sanitize them between uses.

   The challenges of reusable utilization with delivery food service are more pronounced. The fundamental problem in this context is how to "close the loop" by ensuring that customers who have reusable to-go containers return them to the vendor for subsequent use. One possible solution is instituting systems whereby customers are charged a "deposit" for the reusable container which is refunded or credited to their next order when they return the container to the vendor. This would require investment by vendors in the containers themselves and the capacity to clean them, but this could be avoided were the role filled by a third party that supplies to-go containers to vendors while handling collection and sanitization. Such a model may be appropriate for third-party food delivery services (e.g., Postmates, DoorDash), which could incorporate reusables into their operating model with sufficient accommodations from vendors.

E. ***Incentivization Models Using Surcharges:*** One policy option currently enacted, or under consideration by a growing number of California cities, is to place surcharges on disposable food service ware items to incentivize reusable usage. Such policies have been supported in other major urban areas: A San Francisco survey conducted by the Clean Water Fund found that 77% of respondents would support an ordinance that mandated a surcharge on disposable cups to reduce waste and litter.[102]
   There is concern among many food vendors that they will lose customers if forced to mandate a surcharge on certain single-use items, but available survey data and qualitative data provided by interviewed city officials indicate that this is likely a small risk.[103] Universal applicability of such a policy would likely further minimize any transference of business by customers to competitors. However, given the recency with which surcharge policies have been enacted, implementation is ongoing and no quantitative data on the efficacy of these policies is available. It is therefore difficult to determine how the policy would affect consumer behavior in reality.

Compostable and Biodegradable Alternatives

The issue of compostable and biodegradable materials is highly complicated. This complexity makes it difficult to draw firm conclusions about the net impacts of replacing single-use plastic food service ware with compostable or biodegradable alternatives in Los Angeles County. Based on interviews with waste industry consultants, composting facility and anaerobic digester operators, manufacturers, and certifying institutions, the main findings in this area are:

1. While no compostable material can be considered an ideal candidate for food service ware in the County at this time, displacement of single-use plastic food service ware with compostable products will likely produce some benefits. 100% fiber-based

[102] Clean Water Action/Clean Water Fund. (2016). *Reducing Litter and Achieving Zero Waste by Charging for Take-Out Cups A Survey of Customer and Café Behaviors and Response to a Proposed Ordinance in San Francisco.*

[103] Ibid.

items that are free of per- and polyfluoroalkyl (PFAS) or other chemical coatings and which are manufactured from agricultural byproducts appear to be the best option. Evidence suggests that usage of such products will increase food waste diversion rates, reduce the burden on solid waste disposal systems, and degrade more readily should the items be littered. These items are also more conducive to being integrated into composting operations than bioplastic equivalents.

2. There is a major disconnect between the specifications of products being certified and manufactured and what is compatible with composters and digesters in the Los Angeles region. It may be helpful to consider potential steps that public agencies can take to bridge this gap. Such efforts could assist in creating more viable end-of-life disposal options for compostable materials, whether for food service ware or other product categories.

Defining Compostable and Biodegradable

In considering plastic alternatives it is important to distinguish between what defines "compostable" versus "biodegradable" products. In the context of packaging these are technical terms, whose definitions are linked to specific certification standards. These standards are contingent on materials being in the right environment, such as a composting facility, which meets requisite requirements for moisture level and temperature in the item's environment. Items of this nature that are littered, therefore, are almost never in the ideal environment to break down. Some materials may do so, but the time frame required will be significantly longer than in a composting facility.

The primary certifying body for compostable and biodegradable products in the United States is the nonprofit Biodegradable Products Institute (BPI). BPI certifications were originally developed in conjunction with the United States Composting Council and are based on a set of standards called ASTM (American Society for Testing and Materials) D 6400 and ASTM D 6868. The certification process tests products across numerous criteria, including timeframes necessary for physical disintegration and biodegradation, plant toxicity, and heavy metals.

The key difference between biodegradable and compostable products, as defined in ASTM standards, is the result of degradation. Biodegradable items may leave certain undesirable residues at the end of their breakdown process. In contrast, compostable materials break down to organic matter. Compostable is therefore a more stringent standard.

All BPI-certified compostable products meet the same standard, regardless of their specific material type. In addition to the requirements regarding toxicity and potential contaminants, the two most pertinent aspects of the certification are:

1. ***Disintegration:*** The product must degrade into small pieces (no more than 10% by weight exceeding 2 millimeters in size) within 90 days.[104]
2. ***Biodegradation:*** The product must chemically degrade (90% absolute biodegradation) within six months.[105]

Major Categories of Compostable Materials

There are several different types of materials that can be used to manufacture compostable food service ware:

A. ***Paper:*** A familiar material that can be used to manufacture a variety of products. However, some paper-based products such as cups for hot liquids may contain additional coatings or chemicals.

B. ***Fiber-based:*** Material made from the fibers of plants such as sugarcane, sorghum, and bamboo. Some types, such as molded pulp or bagasse, are manufactured from the leftover material produced by agriculture, lowering overall impacts. Such containers may have coatings of other materials or chemicals when intended for liquids.

C. ***Bioplastics:*** Plastic resins made from plant materials. The most common type is polylactic acid (PLA). These substances can be used to make entire products (e.g., clear drinking cups almost indistinguishable from PET) or in combination with other materials (e.g., a PLA coating inside a paper cup).

104 Biodegradable Products Institute (2019). BPI Certification Scheme. *Biodegradable Products Institute*. Retrieved December 12, 2019, from https://bpiworld.org/resources/Documents/BPI_Certification_scheme_2019.pdf

105 Ibid.

Comparative Life Cycle Impacts of Compostable Food Service Ware

Existing research on the life cycle impacts of compostable food service ware compared to non-compostable products paints an unclear picture. Studies vary considerably in what products they compare, what scenarios they consider, and what impact categories they examine, making side-by-side comparisons difficult.

A 2009 assessment comparing PLA, PET, and polystyrene (PS) clamshells found that PS was preferable to PLA across most impact categories, including global warming, air pollution, and impacts on aquatic environments.[106] However, this study was narrowly focused and did not consider some negative ecological impacts associated with PS, such as the detrimental effects to wildlife that inadvertently consume the material. In contrast, another study, published in 2008, focused on starch-based biodegradable and compostable versus single-use plastic cutlery. In this instance, the compostable alternative was found to have significantly lower impacts across all categories, including greenhouse gas emissions, solid waste generation, and eutrophication.[107] While these are only two examples, they illustrate the difficulty of making firm conclusions regarding whether increased compostable food service ware usage will be an environmental boon or not. More research is needed on the environmental impacts of compostable products, but studies conducted so far tend to focus on bioplastics. Other categories of compostable products are even less well-examined.

A 2017 report by Wageningen Food & Biobased Research in the Netherlands succinctly outlines how assessing compostable products' life cycle impacts is complicated by how one values certain categories of environmental impacts. In discussing the role of bioplastics:

> "Substitution of fossil-based plastics by bio-based plastics generally leads to lower non-renewable energy use (NREU) and greenhouse gas (GHG) emission. The GHG emission reduction, however, may be negatively influenced by direct and/or indirect land-use change.... For the categories related to agriculture, such as eutrophication and acidification, bio-based plastics generally have a higher impact than fossil plastics.... No absolute rule can be given."[108]

One of the most thorough reviews of extant research on this topic is the 2018 report by Franklin Associates to the Oregon Department of Environmental Quality.[109] Across numerous impact categories — including global warming impact, land occupation, eco- and human toxicity, and aquatic impacts — compostable food service ware products were found to perform worse, in every one. A major driver of the highest-impact categories for compostable products was their production phase. The analysis also found that, depending on the exact scenario, disposal of compostable food service ware through composting may generate the same or greater impacts than other disposal options.

However, it is notable that only seven studies were considered in reaching these conclusions, underscoring the relative dearth of available research analyzing life cycle impacts of compostable food service ware. Additionally, in casting the proverbial wide net, the authors included some older studies that may not be reflective of current conditions.[110] This report also faces shortcomings with regard to distinguishing among categories of compostable materials; in particular, fiber-based materials made from agricultural byproducts are a notable category whose production impacts would be significantly lower than compostable products made from dedicated crop stocks. Widespread adoption of such materials

[106] Madival, Santosh, Rafael Auras, Sher Paul Singh, Ramani Narayan (2009). Assessment of the environmental profile of PLA, PET, and PS clamshell containers using LCA methodology. Journal of Cleaner Production 17(13), 1183-1194. DOI: 10.1016/j.jclepro.2009.03.015

[107] Razza, Francesco, Maurizio Fieschi, Francesco Degli Innocenti, Catia Bastioli (2008). Compostable cutlery and waste management: An LCA approach. Waste Management 29(4), 1424-1433. DOI: 10.1016/j.wasman.2008.08.021.

[108] van den Oever, Martien, Karin Molenveld, Maarten van der Zee, Harriette Bos (2017). Bio-based and biodegradable plastics - Facts and Figures. Wageningen Food & Biobased Research number 1722. http://dx.doi.org/10.18174/408350

[109] Mistry M, Allaway D, Canepa P, and Rivin J (2018). Material Attribute: COMPOSTABLE – How well does it predict the life cycle environmental impacts of packaging and food service ware? State of Oregon Department of Environmental Quality. Retrieved December 12, 2019, from https://www.oregon.gov/deq/FilterDocs/compostable.pdf

[110] Allaway, J., M. Rivin, M. Mistry, P. Canepa (2019). Environmental Impacts Of Packaging Options. Biocycle 60(3), 30. Retrieved December 13, 2019, from https://www.biocycle.net/2019/03/11/environmental-impacts-packaging-options/

would contribute to the formation of a circular packaging economy, with estimated equivalent benefits in the hundreds of billions of dollars.[111] It is therefore important that the County consider compostable alternative materials on their individual merits as opposed to data generalized across the diverse compostable products sector.

A final major factor to consider is the role of compostable food service ware in the food waste stream. The environmental footprint of food and its associated waste dwarfs that of food packaging, particularly with regard to climate-related impacts.[112] Packaging design and materials can play a significant role in reducing food waste and increasing landfill diversion. Even small differences in wasted food resulting from the type of packaging used can dominate impact differences associated with the packaging itself.[113] This means that, from an environmental perspective, packaging that uses more material may be preferable to minimalist packaging if the bulky packaging leads to lower amounts of residual, non-consumed food. Furthermore, use of compostable food service ware by food vendors has been linked to higher rates of food waste capture, which would likely assist the County in complying with regulations set forth by Senate Bill 1383 regarding organic waste disposal.[114] While the referenced study does not establish a causal relationship between compostable usage and food waste diversion, one possible explanation is that the use of compostable materials prompts customers to dispose of both packaging and food waste together in an organic waste receptacle.

End-of-Life Disposal Considerations

Ensuring that desirable end-of-life options exist for compostable items in Los Angeles County is currently a difficult proposition. Challenges related to disposal, in turn, have consequences for a product's lifetime environmental impacts. The question of disposal is thus one of the primary confounding factors that makes it challenging to assess the magnitude of potential benefits arising from displacing single-use plastics with compostable materials in the County.

However, even when ideal outcomes are not achieved (e.g., a compostable item becomes litter or is sent to a landfill), there are marginal benefits to be had by transitioning from single-use plastic food service ware to those that are compostable. Nonbioplastic compostable products will break down in a landfill setting — though the rate at which they do so varies depending on individual landfill conditions — reducing the solid waste burden on facilities compared to plastics.[115] This process is known to contribute to greenhouse gas emissions, particularly through production of methane via anaerobic decomposition of organic material.[116] However, emissions production can be ameliorated using various strategies, including aerobic landfill operation and capture and combustion of gas.[117] Furthermore, recent research has found that plastics can also produce methane and other hydrocarbon gasses during degradation, suggesting that the relative emissions profiles of plastics and organics during their disposal stage are more similar than historically thought.[118] With regard to a littering scenario, conversations with experts indicate that fiber-based products will degrade in the natural environment significantly faster than plastics, though not nearly as quickly as they would in conditions created in a composting facility.

The primary challenges related to disposal of compostable materials are:

A. ***Feasibility of Degradation:*** The primary concern

[111] Guillard, V., Gaucel, S., Fornaciari, C., Angellier-Coussy, H., Buche, P., & Gontard, N. (2018). The Next Generation of Sustainable Food Packaging to Preserve Our Environment in a Circular Economy Context. Frontiers in nutrition, 5, 121. doi:10.3389/fnut.2018.00121.

[112] Suggitt, Jackie (2018). The link between food waste and packaging. GreenBiz. Retrieved from https://www.greenbiz.com/article/link-between-food-waste-and-packaging

[113] Wilkstrom, F., H. Williams, G. Venkatesh (2016). The influence of packaging attributes on recycling and food waste behaviour — An environmental comparison of two packaging alternatives. Journal of Cleaner Production 137, 895-902. http://dx.doi.org/10.1016/j.jclepro.2016.07.097.

[114] Ekart, Dale and Kate Bailey (2019). Maximizing food scrap composting through front-of-house collections at food establishments. Eco-Cycle. Retrieved December 13, 2019, from http://www.ecocycle.org/files/pdfs/Reports/front-of-house-composting-study-ecocycle.pdf

[115] Lou, X.F., and J. Nair (2009). The impact of landfilling and composting on greenhouse gas emissions - A review. Bioresource Technology 100(16), 3792-3798. https://doi.org/10.1016/j.biortech.2008.12.006.

[116] Ibid.

[117] Ibid.

[118] Royer S-J, Ferrón S, Wilson ST, Karl DM (2018). Production of methane and ethylene from plastic in the environment. PLoS ONE 13(8): e0200574. https://doi.org/10.1371/journal.pone.0200574.

with compostable materials expressed by four of four composting and organic disposal operators interviewed (three in Southern California, one in Northern California) is that products do not disintegrate in the timeframes necessary for their business model. The 90-day disintegration standard met by products certified by BPI is insufficient for many facilities, which may operate on cycles as short as five weeks and an average of approximately 60 days. Additionally, operators indicated that inconsistency of conditions with regard to moisture, temperature, and oxygen availability can lead to compostable materials not performing as certified.

None of the three Southern California-based composting operators currently accept compostable packaging (other than food-soiled paper, which is required by law). One Northern California-based facility indicated that it does compost materials like PLA bioplastic, but that it requires the material to be screened and reintroduced for multiple composting cycles, illustrating the difficulties posed by processing such items. Another operator discussed a facility outside the state where PLA is readily handled thanks to the high temperatures the facility maintains. Overall, experts on the Southern California waste landscape highlighted 100% fiber-based products as the best existing option for being processable, as they would be the least disruptive to their current operations. Products that are more lightly constructed also tend to break down faster.

In the case of anaerobic digesters (ADs) — facilities that process organic waste to create natural gas for energy production — compostable products create other challenges. Mainstream ADs typically process a highly liquid slurry that is primarily composed of food waste, making solid packaging material undesirable. High-solids ADs process solid organic material like leaves in conjunction with food waste, making compostable packaging marginally more processable by such facilities. However, in both cases, compostable packaging represents a loss of output, and therefore a loss of income, for the facilities. Compostable packaging, especially bioplastics like PLA, is nitrogen-poor and low in energy content. Any amount of compostable packaging processed by an AD displaces an equivalent amount of organics that would produce more natural gas, and as such it is counterintuitive for digesters to process such material. However, there are no significant technical barriers, meaning that operators could process compostable products with appropriate incentives.

B. ***Separation of Contaminants:*** All Southern California-based operators interviewed (three of three) indicated that there are issues with efficiently separating compostable products from noncompostable ones. In many cases, the products are indistinguishable at a glance. This is especially true with bioplastics, which often bear significant resemblance to traditional plastics like PET. Therefore, operators separate all packaging as a rule because they do not have the time and resources to filter items reliably. In response to this issue, composting operators indicated that thorough, obvious labeling that is consistent on a region or even statewide basis would likely be helpful. Multiple industry experts have recommended as a model Washington State's House Bill 1569, which requires labeling for compostable products that is "distinguishable on quick inspection" while prohibiting deceptive labels on products that are not environmentally friendly.[119]

C. ***Organic Certification and Markets:*** Organic farms are a key market for many California-based composting facilities. Even when destined elsewhere, composters value an organic certification for their compost product as a testament to its quality. The standards for organic certification are set by the Organic Materials Review Institute (OMRI). These standards do not currently address the incorporation of compostable material into the compost waste stream, meaning that facilities that do so perceive a risk of losing their certification. As a result facilities are erring on the side of caution by excluding compostable materials. This exclusion applies to both bioplastics and fiber-based or paper-based products, the latter of which may have chemical or

[119] H.B. 1569, 2019-20 Biennium, 2019 Reg. Sess. (Wash. 2019).

plastic coatings and treatments. The one operator interviewed that indicated it currently composts PLA and other compostable materials stated that it maintains two separate waste streams, one organic and one nonorganic.

BPI is currently working to have include compostable materials in OMRI standards, which could potentially remove this barrier. However, at this time, the concerns of composters regarding organic certification is a significant source of reluctance to accept compostable materials.

D. ***Item Composition:*** Some types of compostable products may be manufactured with PFAS chemicals. Two interviewed operators noted this as a particular problem with fiber-based products. PFAS compounds have come under increased scrutiny in recent years due to concerns about their impacts on human health, which may include immunological problems and carcinogenic impacts.[120] Given that agriculture is the primary market for composters in California, PFAS contamination is a threat from both business and public health standpoints. Operators expressed the need for greater transparency on the part of manufacturers regarding what their products contain. BPI is implementing a new standard for certified compostable food service ware that will prohibit inclusion of PFAS chemicals.

Economic Considerations

Adoption of compostable food service ware in place of other disposables does not significantly change the business model for food vendors but it would likely result in increased expenditures for food service ware items. Compostable items are generally more expensive than plastic equivalents, such as those made from PET or polystyrene foam, across all categories. However, assuming a reasonable adjustment period, a transition to compostable products is unlikely to cause significant economic disruption. This conclusion is based on the following considerations, with information derived largely from interviews with eight California cities that have enacted policies restricting plastic food service ware items and three compostable product manufacturers.

1. ***Past Experience:*** Policies restricting certain types of plastic food service ware have been enacted in over 100 California cities and counties, and at this time no instance of a food vendor shuttering due to the effects of such a policy has been identified. Most policies of this type have historically included language allowing businesses to apply for exemptions due to economic hardship. Of the eight cities interviewed a majority never received any exemption applications, and only one has granted any exemptions. The argument has been made, however, that businesses are reluctant to engage with the exemption process due to the information they are required to provide, and that therefore the lack of exemption applications may not be reflective of true conditions.
2. ***Small Magnitude Per-Unit Cost Increases:*** While the relative cost increases for compostable items on a per-unit basis can be proportionally high in some categories compared to plastic items, these increases are typically less than 5 cents per item and may be fractions of a cent for small items like straws and utensils. This suggests that businesses can, if need be, pass these minor cost increases on to their customers. Additionally, the item types with the highest proportional per-unit cost increase are those that have been subject to “upon customer request” issuance requirements in previously enacted policies, reducing the fiscal impact on businesses by lowering the quantities of such items used. These considerations are discussed in more depth with respect to expanded polystyrene products below.
3. ***Market Conditions:*** According to compostable product manufacturers, market conditions in the Los Angeles region are such that economic disruption from new adoption of compostable food service ware would be minimal. This is primarily thanks to the presence of many suppliers, driven in large part by the recent uptick in demand and changes in consumer preference toward compostable products. Current market conditions are therefore consumer-favorable with regard to prices and providing sufficient supply to meet increased demand.

There can also be notable economic benefits for busi-

[120] Cohen, Albert M (2019). PFAS Under Increased Scrutiny in California. *Lexology.* Retrieved December 13, 2019, from

nesses of utilizing compostable food service ware. A case study of a Seattle-based restaurant chain that transitioned to 100% compostable service ware showed that it has seen significant positive effects since switching to compostable service ware, including increased brand awareness and a growth in sales of 47% between 2010 and 2015.[121] The business was also able to increase the amount of compost it generated from approximately 200 tons in 2011 to over 1800 tons in 2015.[122] Adoption of a single-bin system was reported to have reduced confusion among customers and resulted in lower costs associated with collection and disposal. This strategy may have the potential to produce significant long-term savings with regard to waste collection if adopted in Los Angeles County.

Plastic Alternatives

There are limited situations where transitioning from one type of plastic food service ware item to another type of plastic is beneficial. An example of such a transition would be shifting from PS or EPS to PET. Doing so could be a means of minimizing the usage of resins that have particularly harmful human health or environmental impacts. However, the aforementioned difficulties with recovering and recycling plastic food service ware, regardless of its resin type, would remain.

Price Comparison of Expanded Polystyrene Versus Alternatives

Pricing of expanded polystyrene food service ware versus other disposable alternatives bears special mention. Expanded polystyrene products have been the most commonly restricted plastic material in California, due in large part to their notable negative impacts on marine ecology, challenges for recycling, and impacts on human health. However, these products have a reputation as the cheapest option available to many food vendors for disposable ware, and the California Restaurant Association expressed concern that transitioning to alternatives would be fiscally infeasible for many food vendors in Los Angeles County.

One of the most thorough studies of relative pricing between expanded polystyrene and alternative material food service ware items was conducted by Cascadia Consulting Group in 2012. This assessment preceded a potential expanded polystyrene ban in the City of San Jose and focused on the economic effects on businesses.[123] This study gathered data from several different food service ware suppliers and reported the lowest cost they found for expanded polystyrene and alternatives. Alternatives included other plastics besides expanded polystyrene, fiber-based products, and PLA products.

Regarding clamshells, Cascadia found the lowest-priced alternative to be other plastics, with the price difference ranging from $0.05 to $0.26 greater than expanded polystyrene. For cold cups, the difference between expanded polystyrene and fiber-based cups was extremely small, with the cost for fiber cups to be only $0.003 to $0.01 greater than expanded polystyrene cold cups.[124] Fiber-based hot cups were found to be cheaper than expanded polystyrene cups in some cases, with a price difference between $0.017 less and $0.009 greater than expanded polystyrene. The difference for fiber-based plates was between $0.01 less and the same price as expanded polystyrene plates.[125]

These results show that the price differential between expanded polystyrene and alternative food service ware is quite small and, in some cases, alternatives are actually cheaper. Additionally, prices for alternative products have been trending downward in recent years thanks to economies of scale and increased popularity, indicating that price differentials may be smaller now than when this study was conducted in 2012. In conversations with compostable manufacturers, many noted how their products have become more affordable over time.

Additionally, a 2012 report done by Economic & Planning Systems for the City of San Jose analyzed the economic impact of expanded polystyrene bans on restaurants and

[121] NatureWorks | Taco Time Embraces Seattle Waste Ordinance. (n.d.). Retrieved December 16, 2019, from https://www.natureworksllc.com/In-geo-in-Use/CaseStudies/Taco-Time-Embraces-Seattle-Waste-Ordinanc

[122] Ibid.

[123] Cascadia Consulting Group. (2012). *EPS Food Service Ware Alternative Products - An Evaluation of Costs and Landfill Diversion Potential.*

[124] Ibid.

[125] Ibid.

found no severely detrimental effects of existing bans on the restaurant industry.[126] There were no reports of any food establishment going out of business because of an expanded polystyrene ban and, while most cities offered some form of financial hardship exemption, no financial hardship applications were reported. Scenario analysis of profit margins for full- and limited-service restaurants found no case in which an establishment would have a post-ban profit margin below zero, suggesting that while the cost increase will impact food vendors using expanded polystyrene, the impact is of insufficient magnitude to render the vendor financially unsustainable.[127] Furthermore, analysis of customer elasticities in response to price increases at restaurants found that there is generally an inelastic customer demand to price increases and a generally elastic demand for different restaurants.[128] This means that any increase in prices instituted by a food vendor to cover increased food service ware costs would likely not result in a significant reduction in customers.

[126] Economic & Planning Systems, Inc. (2012). *Economic Impact Analysis of EPS Foodware Costs*.
[127] Ibid.
[128] Ibid.

VII. policy process and design lessons from cities with existing plastics policies

In California, 135 cities and counties have adopted ordinances related to single-use plastic reduction.[129] We performed extensive research to better analyze the history and effectiveness of these policies. To further evaluate existing regulation in the state, we conducted a series of eight interviews with city officials who have implemented plastic policies to gain more insight into the policy process and design, as well as the lessons learned from their experience. To enhance the quality of information obtained, identities of city officials remain confidential throughout this report.

In this section, we provide background information relating to the general history of California plastics regulation both statewide and citywide, notably concerning plastic bags and polystyrene/expanded polystyrene ordinances. Next, we discuss our qualitative city interview findings, first examining respective policy development and rationale then transitioning to policy implementation. Transition periods, the stakeholder engagement process, and public education are the specific focuses of analysis here. Once development and implementation are identified, we discuss cities' policy execution including challenges and areas for improvement, post-policy effects and subsequent impacts on affected businesses.

Key Findings:

- Plastic bans have been proved to be effective at reducing plastic waste, with results from Senate Bill 270's plastic bag ban revealing a significant decrease in plastic bag use in California.
- All (eight of eight) city interviewees noted negative environmental impacts and litter as the two main rationales behind all respective plastic ordinances.
- The lack of recyclability for many plastics, especially polystyrene, was an added justification by many cities.
- Policy enforcement proved to be the main challenge for many early-adopter cities.
- No negative effects were reported by any city official we interviewed post-implementation of their policy.

SB 270 Sets a Plastic Precedent in California

Historically, policies designed to reduce plastic waste in California have predominantly focused on two categories of products: lightweight plastic bags and polystyrene. Plastic bag bans were first implemented in various cities throughout the state in 2008 and have become highly publicized in years since.[130] Due to the positive effects of these citywide initiatives, California became the first state to pass a Single-Use Carryout Bag Ban (SB 270) in 2016, with close to 150 cities having already adopted some sort of plastic bag restriction prior to the statewide rule.[131] SB 270 prohibits grocery stores, certain retail stores, convenience stores, and liquor stores from providing single-use plastic carryout bags to customers. In lieu of plastic, the affected stores can instead provide

[129] (C. Cadwallader, personal communication, January 6, 2020)
[130] List of Local Bag Bans. (n.d.). Retrieved December 16, 2019, from https://www.cawrecycles.org/list-of-local-bag-bans
[131] Single-Use Carryout Bag Ban (SB 270). (n.d.). Retrieved December 16, 2019, from https://www.calrecycle.ca.gov/plastics/carryoutbags

customers with a reusable tote or recycled paper bag for a minimum of 10 cents.[132]

A post-evaluation study conducted by CalRecycle reveals significant reduction rates for plastic bag usage as a result of the policy.[133] Within a six-month period, close to 66 million reusable bags and 45 million recycled paper bags were reportedly sold to customers post-SB 270.[134] In contrast, approximately 435 million single-use plastic bags and 116 million paper bags were sold to customers before policy implementation.[135] These numbers represent an 85% decrease in the number of plastic bags distributed and a 61% decrease in the number of paper bags distributed to customers.[136]

Positive effects were observed regarding litter reduction as well. Pre-policy, 8-10% of littered items collected in California were paper or plastic bags. In 2017 post-policy, the percentage of plastic and paper bags collected decreased to 3.87% of the litter stream.[137] A report released by UCLA in partnership with the City of Los Angeles Bureau of Sanitation estimated that close to 11,400 tons of litter will be diverted in 2020 alone as a result of the plastic bag ban.[138] These findings demonstrate that large-scale bans on products or materials are effective in reducing plastic waste and litter.

Single-Use Plastic Regulation in California Cities

In addition to plastic bag bans, several cities have adopted other policies to reduce plastic including, but not limited to, bans on latex ballons, expanded polysterene, and plastic straws (or straws provided upon request only). In California, there are currently 135 local ordinances, either city or countywide, restricting plastics. Historically, the majority of these policies have focused on expanded polystyrene or polystyrene products (see Appendix A and C).[139] Many of these policies have been in place for a long time, with Berkeley being the first city to pass an expanded polystyrene ban in 1988.[140] Within L.A. County, 13 cities have an expanded polystyrene or polystyrene ban (see Appendix B). Several cities have transcended an initial expanded polystyrene ban and implemented more stringent policies concerning single-use plastics. The development of recent ordinances has demonstrated city/county efforts to dramatically reduce regional waste and develop more sustainable solutions to the challenges posed by plastics.

Interviews With City Officials

We conducted eight interviews with California city officials who have enacted stringent single-use plastic reduction policies in order to gain insight into respective processes and lessons learned. Officials from five cities in Los Angeles County were interviewed in addition to officials from three cities outside the County. Information was gathered regarding policy development, implementation, and execution processes. We were also able to gather information related to post-policy effectiveness and current challenges/areas for improvement.

1. ***Policy Development and Respective Rationale:*** We sought to understand the rationale behind these policies to further determine initial purpose and ultimate effectiveness. Unsurprisingly, litter and its subsequent impact on marine environments was noted as primary motivation for policy development from all city representatives, most crucially by the two coastal cities that were interviewed. Economic interests were additionally referenced by all, either related to cleanup costs or tourism revenue loss concerns.

   A lack of recyclability for many plastics, especially polystyrene, was cited as additional policy justification by several cities. Officials discussed the lack

[132] Ibid.

[133] *SB 270 Report to the Legislature: Implementation Update and Policy Considerations for Management of Reusable Grocery Bags in California. (2019, February 25), 40.*

[134] Ibid.

[135] Ibid.

[136] Ibid.

[137] Ibid.

[138] *City of Los Angeles Zero Waste Progress Report (2013).* (p. 48).

[139] Table View PS Ordinance. (n.d.). Retrieved December 16, 2019, from https://www.cawrecycles.org/psordinancetable

[140] Berkeley11.pdf. (n.d.). Retrieved from https://www.codepublishing.com/CA/Berkeley/html/pdfs/Berkeley11.pdf

of a market for polystyrene and others, stressing economic inefficiency for local recovery facilities to recycle the material. While a few officials stated that the negative impacts of plastic on human health were a topic of discussion, only one city official stated that health-related impacts were enough of an impetus for policy implementation. Notably, however, a handful of cities agreed that a reduction in negative health impacts would prove an added benefit resulting from the policy.

2. ***Policy Implementation:*** Many cities proved to share similar policy implementation processes including transition period mandates, extensive stakeholder engagement, and education/awareness campaigns.
   a. ***Transition Periods:*** All cities interviewed granted a minimum six-month "grace period" in order to give businesses enough time to use up their current stock of products and to develop a plan for transitioning to compliant alternatives. This delay allowed for internal adaptation, especially concerning subsequent modifications to business operations. For one city, the transition period proved much longer (almost triple in length) and was strongly advised against. For the cities with the most stringent plastic policies, many employed a phase-in approach comprising an initial policy that banned only expanded polystyrene or polystyrene food service ware, for example, then a second phase banning the retail sale and distribution of most polystyrene products.
   b. ***Stakeholder Engagement Process***: Several cities took a proactive approach to the stakeholder engagement process. Pre-policy implementation, many officials noted citizens and businesses were provided with ample resources needed to understand the purpose of the policy as well as the relevant details and timeline. Once passed, many cities sent mailers to all affected stakeholders to raise awareness of initial policy implementation. Workshops were also used as an educational tool, providing businesses with compliant product samples or brochures including a list of compliant materials by product category. One unique strategy described was the creation of an explanatory video for affected businesses, distributed along with a brochure of compliant products.
   c. ***Public Education and Awareness:*** Public education and outreach were a top priority for all city officials interviewed. To maximize public awareness, several city teams created explanatory flyers in multiple languages for diverse constituents. The majority of the cities stated that the public reception has been mostly positive and that most people in the community have been in favor of the ordinance. Several mentioned that their citizens welcomed the ordinance as they wanted to help make a positive impact on their community.
3. ***Challenges and Areas for Improvement:*** City officials expressed a shared primary challenge concerning policy enforcement. Ensuring compliance for businesses proves difficult and demanding considering the sheer number of firms and varieties in one region. With a lack of resources notably including time and staff, most cities have been unable to monitor compliance. Instead, many city officials interviewed rely on a simple complaint-based system, transferring responsibility to local customers and employees. One city allows citizens to report violations through an app, making the complaint process easy and convenient.

   The city exhibiting the strictest enforcement system has an inspector personally "audit" every restaurant to ensure businesses are complying with the ordinance. Yet due to the time-consuming process that this requires, inspectors have yet to visit every affected establishment after more than two years since the policy's enactment date.

   Additionally, challenges regarding city borders were raised, particularly when neighboring cities do not have a policy in place. Food truck vendors are especially impacted in this capacity and compliance assurance is nearly impossible given that many vendors cross city borders daily. Multiple officials also noted that although they have seen positive effects from their respective policies, due to variability by city, confusion for citizens and businesses can ensue.

Another issue discussed was the preferred alternative to the banned food service ware materials. While one city official cited 100% fiber-based as a preferred alternative, another was concerned that these products can contaminate the recycling stream if not disposed of correctly. However, it is unlikely that such products would represent a marginal increase in the contamination of recycling compared to the status quo, even in a worst-case scenario.

4. ***Policy Execution and Effects:*** It is important to note, for the purpose of this report, that we were unable to access city-specific quantitative data pertaining to post-policy effects of respective ordinances. Although statistics are limited, city officials observed a reduction in litter based on anecdotal evidence, especially with regard to polystyrene. This information has not been historically tracked by municipalities, in part due to logistical difficulties, and information available through nongovernmental organizations can be inconsistent in its methodology.

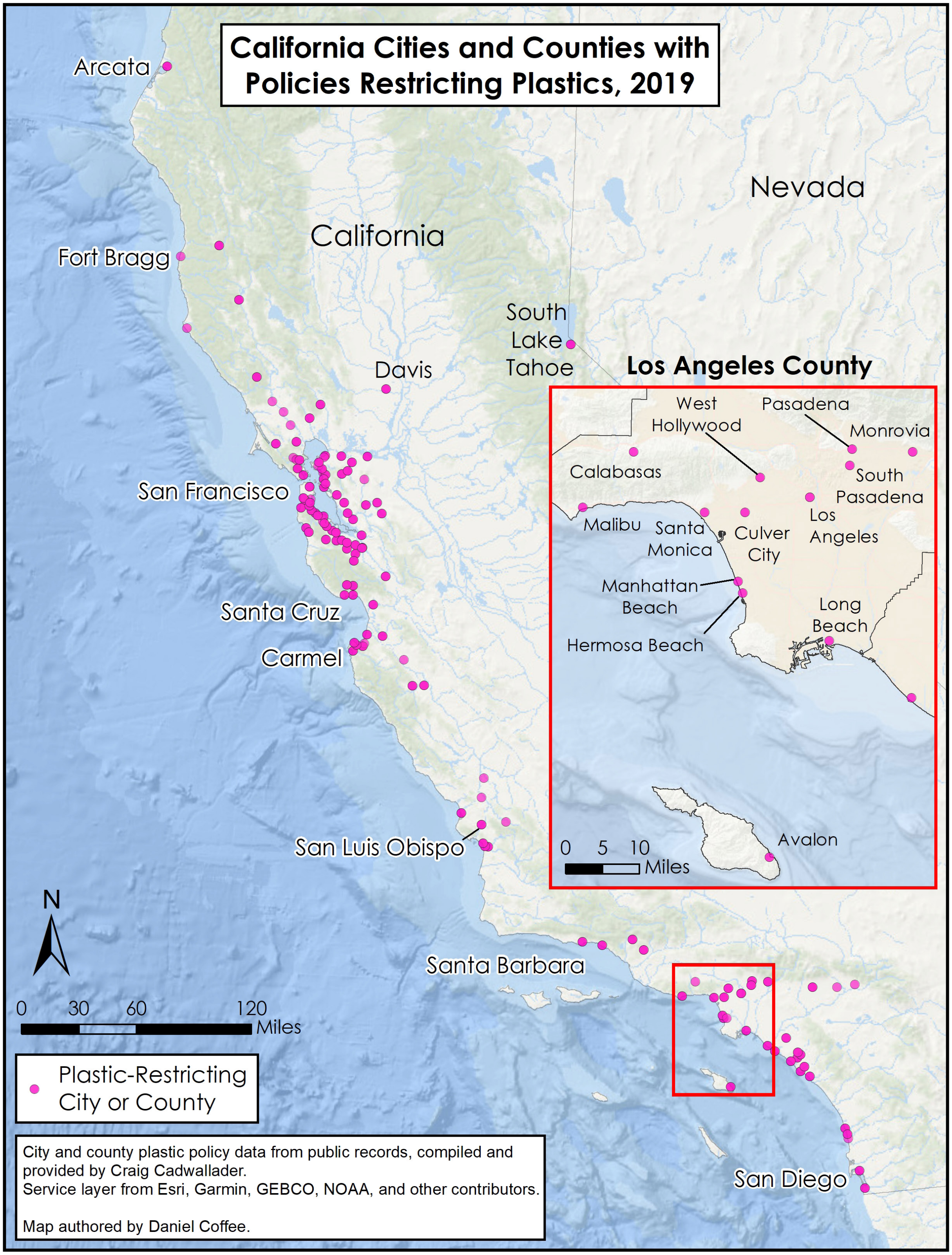
   The lack of quantitative litter data pre- and post-policy proved a common issue for many officials we spoke with, making it difficult to accurately assess how effective the policy has been at reducing plastic waste.

5. ***Economic Impact on Affected Businesses:*** Given that these policies directly impact local firms, impacts on affected businesses were top of mind for a majority of the city officials interviewed. Seven of the eight cities interviewed currently offer a financial hardship waiver for businesses, allowing them to express a state of financial distress and need for additional time to purchase compliant product alternatives. A request for an exemption must be filed in writing and sent to the appropriate city manager, along with documentation that proves financial hardship in order to be considered. The only city interviewed that did not include a financial hardship waiver in its ordinance conducted an alternative cost-evaluation study, concluding that only high-volume food providers exclusively using expanded polystyrene would be significantly impacted. This city further determined these vendors to be outliers.

   Our study ultimately revealed that few financial hardship waiver applications have been submitted in all cities interviewed, with waivers being granted only in one-off circumstances. Most cities have instead been successful in finding affordable alternative solutions for businesses that are easily adoptable. Additionally, all cities allow exemptions for businesses with no existing compliant alternative. Only one city official mentioned they have been unable to find an alternative for a very specific product unique to a certain business. Most notably, no negative effects for businesses were reported by any city official post-implementation of their policy.

appendix a

California Cities and Counties With Plastics Restriction Policies (as of January 15, 2020)



appendix b

GOV = Applies only to government facilities

REST = Applies to food service establishments

FULL = Applies to food service establishments and restricts the retail sale of food service ware

Cities in Los Angeles County With Plastics Restriction Policies:

City	Policy	Policy Description	Year Adopted	Type
Calabasas	EPS Ban	Expanded polystyrene ban on all food packaging, requirement that all takeout food packaging must be returnable, recyclable, biodegradable, or degradable.	2008	REST
Culver City	PS Ban	Ban on distribution and sale of polystyrene food service ware, requires food providers to provide takeout disposable utensils to customers upon request only. Ban on polystyrene coolers (not encapsulated).	2017	FULL
Hermosa Beach	PS Ban	Iinitial ban inclues polystyrene food service ware. Updated polystyrene ban includes ban on sale and distribution of meat trays, plastic straws, packing materials and Mylar balloons .	Initial 2012, additional ban in 2019 (updated ban effective in 2020)	FULL
Los Angeles City	EPS Ban	Government facility EPS ban.	1988/2008	GOV
Los Angeles County	EPS Ban	Government facility EPS ban.	2010	GOV
Long Beach	EPS Ban	Expanded polystyrene food service ware ban. Also prohibits the sale and distribution of polystyrene ice chests and polystyrene bean bags. Utensils and straws are provided upon request only for take out orders.	2018 (government facilities), 2019 (food establishments)	REST
Manhattan Beach	PS Ban	Initial ban on polystyrene food service ware. Ban In 2014 prohibits polystyrene coolers, straws, lids, and utensils. 2018 ban prohibits polystyrene egg cartons and packing materials. 2019 ban prohibits polysty-rene meat and produce trays.	Initial in 2013, additional bans in 2014, 2018, 2019	FULL

City	Policy	Policy Description	Year Adopted	Type
Malibu	EPS Ban	Initial ban in 2005 prohibits sale and distribution of polystyrene food containers and packing materials. Additional ban in 2017 prohibits sale and distribution of other polystyrene products including all food service ware, meat and produce trays, egg cartons, packing materials, coolers, pool/beach toys, buoys, as well as plastic sandbags. Additional ban in 2018 prohibits the sale and distribution of single-use plastic and bioplastic straws, stirrers, and utensils.	Initial ban in 2005, additional bans in 2017 and 2018	FULL
Monrovia	EPS Ban	Prohibits the use or purchase of expanded polystyrene products at government facilities.	2017	GOV
Pasadena	PS Ban	Ban on sale and distribution of all polystyrene food service ware (cups, bowls, plates, takeout containers); does not include straws, lid cups, or utensils. Ban includes polystyrene coolers.	2017	FULL
Redondo Beach	PS Ban	Ban on PS food service ware. *Passed January 7, 2020.	2020	
Santa Monica	EPS Ban	Ban on all polystyrene and other nonrecyclable plastic disposable food service containers; requires all food packaging to be marine degradable.	2007, additional ban in 2019	REST
South Pasadena	EPS Ban	Ban on sale and distribution of all expanded polystyrene food service ware for food providers and retail providers.	2017	FULL
West Hollywood	PS Ban	PS ban for restaurants and food vendors.	1990	REST

* **Sources:**

1. Californians Against Waste, Table View PS Ordinance. https://www.cawrecycles.org/psordinancetable
2. C. Cadwallader, personal communication, January 6, 2020

appendix c

California Cities and Counties With Various Plastics Restriction Policies

Alameda (2008/2017)
Alameda County (2015)
Albany (2008)
Aliso Viejo (2004)
Arcata (2015)
Arroyo Grande (2016)
Atascadero (2019)
Avalon (2017)
Belmont (2012)
Berkeley (1988/2019)
Brisbane (2014)
Burlingame (2011)
Calabasas (2007)
Campbell (2014)
Capitola (2009/2011)
Carmel (2008/2017)
Carpinteria (2008/2017)
Colma (2013)
Concord (2018)
Contra Costa County (2019)
Cotati (1989)
Culver City (2017)
Cupertino (2014)
Daily City (2012)
Dana Point (2012)
Davis (2017)
Del Mar (2019)
Del Ray Oaks (2009)
Dublin (2019)
El Cerrito (2013)
Emeryville (2007)
Encinitas (2016)
Fairfax (1993)
Fort Bragg (2014)
Foster City (2011)
Fremont (1990/2010)
Gonzales (2014)
Greenfield (2014)
Grover Beach (2018)
Half Moon Bay (2011)
Hayward (2010)
Hercules (2008)
Hermosa Beach (2012/2019)
Highland (1988)
Huntington Beach (2004)
Imperial Beach (2018/2019)
Lafayette (2014)
Laguna Beach (2007)
Laguna Hills (2008)
Laguna Woods (2012)
Livermore (2010/2018)
Long Beach (2018)
Los Altos (2014)
Los Altos Hills (2012)
Los Angeles City (1988/2008)
Los Angeles County (2008)
Los Gatos (2014)
Malibu (2005/16/18)
Manhattan Beach (1988/2019)
Marin County (2009)
Marina (2011)
Martinez (1993)
Mendocino County (2014)
Menlo Park (2012)
Millbrae (2007)
Mill Valley (2009)
Milpitas (2017)
Monrovia (2017)
Monterey City (2009)
Monterey County (2010)
Morgan Hill (2014)
Moro Bay (2016)

Mountain View (2014)

Newport Beach (2008)

Novato (2013/2014)

Oakland (2006)

Ojai (2014)

Orange County (2006)

Pacific Grove (2008)

Pacifica (2009)

Palo Alto (2009/16/19)

Pasadena (2016)

Paso Robles (2019)

Petaluma (2019)

Pinole (2018)

Pismo Beach (2015)

Pittsburg (1991)

Pleasanton (2013)

Point Arena (2010)

Portola Valley (2012)

Rancho Cucamonga (1988)

Redondo Beach (2020)*

Redwood City (2011)

Rialto (1988)

Richmond (2009/13)

Salinas (2011)

San Anselmo (2018/2019)

San Bruno (2009)

San Carlos (2012)

San Clemente (2011)

San Diego (2019)

San Francisco City/County (2006/19)

San Jose (2013)

San Juan Capistrano (2004)

San Leandro (2011)

San Luis Obispo City (2015)

San Luis Obispo County (2019)

San Mateo City (2013)

San Mateo County (2008/11)

San Pablo (2014)

San Rafael (2012)

Santa Barbara (2018)

Santa Clara City (2014)

Santa Clara County (2012)

Santa Cruz City (2008/12/17)

Santa Cruz County (2012/2019)

Santa Monica (2007/2018)

Sausalito (2007)

Scotts Valley (2008)

Seaside (2010)

Sebastopol (2019)

Solana Beach (2015)

Sonoma City (1989)

Sonoma County (1989)

South Lake Tahoe (2018)

South Pasadena (2016)

South San Francisco (2008)

Sunnyvale (2013)

Ukiah (2014)

Union City (2016)

Ventura County (2004)

Walnut Creek (2014)

Watsonville (2009/14/19)

West Hollywood (1990)

Highland (1988)

Yountville (1989)

**Passed on January 7, 2020

** Source: C. Cadwallader, personal communication, January 6, 2020

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