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Risky Business? Manufacturer and Retailer Action to Remove Per- and Polyfluorinated Chemicals From Consumer Products

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Abstract

In the absence of comprehensive environmental regulation, under what conditions can social movement pressure on the private sector generate substantive change? We explore this question in relation to per- and poly-fluoroalkyl substances (PFAS), a class of persistent, bioaccumulative, and toxic chemicals that are widely used in consumer products and industrial processes yet remain largely understudied and weakly regulated. This paper focuses on the strengths and limitations of one high-profile shame campaign by Greenpeace that has called for clothing and outdoor brands to eliminate PFAS from their products. We find that while the campaign appears to have spurred widespread awareness of PFAS in the apparel industry, corporate action remains fragmented and leaves broader environmental and social justice concerns unaddressed. We highlight the urgent need for comprehensive federal regulation for toxic chemicals, increased funding for green chemistry, and collaborative governance of global production networks.

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Introduction

Recent discoveries of high levels of water contamination in many U.S. communities near industrial and military facilities have fueled both public and scientific interest in a class of chemicals known as per- and poly-fluoroalkyl substances (PFAS). PFAS constitute a prime example of "emerging contaminants," or chemicals in widespread production and use, ubiquitous in the environment and human bodies, with growing scientific evidence of adverse health effects, yet with weak or nonexistent regulation.[1] Exposure to PFAS occurs not only through contaminated drinking water and occupational exposures but also through everyday consumer products such as nonstick cookware, waterproof and stain resistant clothing, food packaging, and cosmetics.[2,3] As we describe below, despite growing concerns over such exposures, U.S. federal regulatory action on PFAS remains severely limited, and no legally enforceable federal restrictions exist for drinking water, though a few states have recently set or proposed regulatory limits.

This paper addresses the following research question: in the absence of comprehensive environmental regulation, under what conditions can social movement pressure generate substantive change by the private sector? The paucity of comprehensive regulation of PFAS has spurred growing advocacy not only directed toward state actors to enact state and federal regulations, but also targeting the private sector. As such, the range of nonregulatory approaches to PFAS governance constitute a rich case through which to examine how and whether negotiations between civil society and the private sector can generate substantive change in toxic chemical production and use. To examine the efficacy of civil society pressure on the private sector, we focus on Greenpeace International's "Detox My Fashion" global consumer campaign, launched in 2011, that calls for major clothing brands, retailers, and suppliers to adopt a fully transparent and precautionary chemical policy, and to eliminate eleven priority chemical groups from manufacturing by 2020. The campaign explicitly calls for the elimination of PFAS as a chemical class and a transition to the use of safer alternatives. Through product testing and corporate shaming tactics, Greenpeace has spurred corporate public response to concerns regarding PFAS use and has played a significant role in influencing companies to commit to eliminating certain PFAS from clothing and outdoor gear. Since 2011, eighty brands, retailers, and suppliers have announced voluntary commitments to reduce or eliminate the use of certain PFAS.

However, this case also demonstrates the limitations of advocacy campaigns that target consumer product companies. Even if companies are persuaded to

improve their chemical policies, they may struggle to gather comprehensive and reliable information about chemical use along the global supply chain[4] as well as the hazards associated with replacement chemicals.[5] Such heavy focus on voluntary elimination of the use of certain harmful chemical classes also overshadows the equally important goal of stimulating corporate and federal investment in the development of functionally equivalent, nontoxic alternative chemicals. Furthermore, broader environmental and social justice concerns remain unaddressed; while the campaign may offer some protections to wealthier consumers in the Global North who purchase expensive goods produced by industry leaders, workers and fence-line communities along the global supply chain remain disproportionately exposed, as there is reason to believe that overall production of PFAS has continued to increase,[6] particularly in China and Southeast Asia.[7] We conclude that while the efforts of advocacy groups and consumers are valuable in stimulating manufacturer and retailer action to reduce the use of emerging contaminants such as PFAS, substantive change is unlikely without comprehensive and precautionary federal regulation, increased funding and incentives for innovation in alternative chemicals, and systematic governance and monitoring of global supply chain networks.

Background

PFAS are a class of human-made chemicals with oil- and water-resistant properties and are found in consumer products including nonstick cookware, clothing, mattresses, carpeting, food packaging, and dental floss.[2] They are also used as surfactants in the aerospace, construction, and electronics industries, and are a common ingredient in firefighting foams used by public, commercial, and military firefighting organizations to extinguish fuel-based fires.[8] Two of the most prominent PFAS were introduced to commerce in 1940s: DuPont's perfluorooctanoic acid (PFOA), used to create Teflon and a byproduct of many other processes, and 3M's perfluorooctane sulfonate (PFOS), used in Scotchguard, firefighting foam, and semiconductor devices.[9] Both PFOS and PFOA are considered "long-chain" PFAS, chemical compounds with more than six or eight carbons, depending on the compound.[10]

The 2000s saw a significant increase in global research on PFOA and PFOS, with contaminated communities catalyzing the discovery of adverse health effects, significant water contamination, and pursuing litigation, all contributing to the growth of attention to the broader chemical class of PFAS.[2,9] Numerous studies have documented the presence of long-chain PFAS in virtually all environmental media, wildlife, and in human blood samples worldwide,[11–13] and explicated human exposure pathways including dust, food packaging, dietary intake, drinking water, and consumer products.[14–17] Toxicology and epidemiology studies have increasingly documented human health effects of exposure to certain PFAS even at low doses, including kidney and liver cancer,

neurotoxicity, allergen and immune system effects, developmental toxicity, and endocrine disruption.[18]

In response to the growing consensus and concern with the toxicity of PFOA and PFOS, chemical companies began producing so-called "next-generation" PFAS chemicals—many of them called "short-chain" PFAS because they contain fewer carbons in the chain—claiming that such varieties would not pose the same risks as their long-chain counterparts because they were less bioaccumulative.[19] However, the purported safety of these alternatives remains contested.[20,21] In May of 2015, the Green Science Policy Institute (a research and advocacy organization in Berkeley, CA, that began with a nationwide campaign to reduce flame retardant usage and later expanded to include PFAS as one of its class-wide sets of chemicals needing regulation, reduction, and replacement) spearheaded the publication of the "The Madrid Statement" in the journal *Environmental Health Perspectives*.[22] The statement was authored by fourteen American and European scientists alongside more than two hundred signatories to present a scientific consensus on the various harmful impacts PFAS as a class of chemicals and echoed the concerns presented in the "Helsingor Statement on poly- and perflourinated alkyl substances (PFAS)," a 2014 report by a group of prominent international scientists calling attention to PFAS and the dangers of relying on short-chain replacement compounds.[23] Both documents highlight that although some shorter-chain compounds appear to be less bioaccumulative, they are still environmentally persistent. Moreover, because shorter-chain PFAS may have lower technical performance, greater quantities may need to be used; hence, a switch to shorter-chain compounds may not reduce the amount of PFAS in the environment.[23]

U.S. federal regulatory action on PFAS has been largely limited to negotiations between the Environmental Protection Agency (EPA) and industry regarding voluntary phase-outs of specific compounds. In the wake of several high-profile PFOA and PFOS soil and water contamination cases in the early 2000s, the EPA established the global PFOA Stewardship Program in 2006, inviting eight major fluoropolymer and telomer manufacturers (Arkema, Asahi, BASF Corporation, Clariant, Daikin, 3M/Dyneon, DuPont, and Solvay Solexis) to commit to eliminating production and emissions of PFOA and its precursor chemicals by 2015.[24] In 2009, the EPA issued a Provisional Health Advisory level for PFOS and PFOA in drinking water[25] followed by a Lifetime Advisory Level in May 2016 for PFOS and PFOA combined.[26] However, the agency has yet to follow up with a legally enforceable maximum contamination level.[27] New Jersey is the only state to have adopted an enforceable Maximum Contaminant Level (MCL) for any PFAS in drinking water,[28,29] though California, Massachusetts, Michigan, New Hampshire, New York, Pennsylvania, and Vermont are in the process of creating regulatory levels and several other states have nonenforceable advisory levels.[30] After facing a nongovernmental organization (NGO) petition, the Food and Drug Administration (FDA)

removed three food contact materials containing phased-out long-chain PFAS from its list of approved materials in 2016.[31,32] There is currently increasing attention to PFAS in food packaging; the State of Washington and the City of San Francisco have finalized bills to implement class-based bans on PFAS in food packaging, and seven other states have proposed similar bills.

Internationally, the regulatory focus has been on longer carbon chain PFAS. In 2009, PFOS was listed under Annex B of the Stockholm Convention on Persistent Organic Pollutants (POPs), meaning that signatories must pursue efforts to restrict (but not eliminate) its production and use.[33] In 2017, PFOA and perfluorohexane sulfonate (PFHxS) were added to the group of compounds proposed for listing under the Convention.[34] Under the European Union (EU) Regulation, Evaluation, Authorization, and Restriction of Chemicals (REACH) program, PFOA and related substances will be regulated in a range of products starting in 2020.[35] Other international efforts toward promoting coordinated regulatory approaches are being pursued by The Organisation for Economic Cooperation and Development (OECD) and the Global PFC Group within the United Nations Environment Program (UNEP).[36]

In the absence of comprehensive regulation, voluntary corporate action to reduce the use of PFAS in consumer products has been disjointed and uneven. In most cases to date, voluntary corporate commitments entail a shift from the use of long-chain to short-chain PFAS, rather than an elimination of the whole chemical class.[6] Such is the logic that guides the policies of the Zero Discharge of Hazardous Chemicals (ZDHC) Group, which is an industry-organized group established in response to the launch of the Greenpeace Detox campaign in 2011. The ZDHC's Joint Roadmap outlines a goal to eliminate the discharge of certain hazardous chemicals along the supply chain by 2020.[37] Signatories include several major clothing companies, with some overlap in participation in the Greenpeace Detox campaign. While the "intentional use" of long-chain PFAS has been banned under the ZDHC Manufacturing Restricted Substances List, proposed alternatives include short-chain fluorinated compounds. Due to the widespread industry characterization of short-chain compounds as safe alternatives, supply chain companies and chemical manufacturers are able to present such transitions as environmentally conscious.

Environmental organizations including Environmental Working Group, Green Science Policy Institute, the National Resources Defense Council, and the Safer Chemicals, Healthy Families coalition have pressed companies to remove all PFAS from their products. Largely as a result of such environmental advocacy pressure, a few large companies including IKEA, Crate and Barrel, Levi's, and Kaiser Permanente publicly committed to eliminating the use of PFAS as a class of chemicals.[38] In Europe, some manufacturers and retailers have voluntarily decreased the use of PFAS, framing PFAS phase-outs as a chance to attract more customers, increase loyalty, and to gain competitive advantage. In the summer of 2015, Coop Denmark, Denmark's largest retailer,

decided to recall its store-brand microwave popcorn made with packaging that contained fluorinated chemicals from more than twelve hundred, stores.[39] In less than a year, a supplier successfully developed effective packaging made of natural cellulose and without fluorinated chemicals. Such examples constitute exceptions to the broader trend of piecemeal changes in chemical use by a few companies and for a limited number of PFAS.

Literature Review

Toxic Chemical Governance

While chemical management policy in the United States has considerably improved since the 1970s, it has not kept pace with the rapid expansion in chemical production and scientific information about chemical hazards. Industrial chemicals are regulated by the Toxic Substances Control Act (TSCA), yet substantive exposure and toxicity testing has only been conducted on a small fraction of more than eighty thousand chemicals on the market, and many chemicals suspected of being hazardous can be found in consumer and commercial products.[40,41] In the original TSCA statute, it was nearly impossible for the EPA to ban chemicals,[42,43] and the evaluation of newly developed chemicals also was limited. Under the "new TSCA" based on 2016 reform, the EPA must affirm the expected safety of newly developed chemicals, and can collect some funds from chemical companies to pay for part of their reviews. However, the act requires the EPA to review only twenty high-priority chemicals at a time and limits states' ability to take action on chemicals of concern once the EPA begins to review them. While chemical manufacturers must submit a premanufacture notification for proposed new chemicals to the EPA, they do not have to provide evidence of chemical safety.

Supply chain companies and retailers, then, are left to navigate several realms of uncertainty surrounding chemical manufacturing processes and chemical safety. Even if companies seek to improve their chemical policies, they may not be able to reliably control chemical contamination in manufacturing, given the lack of thorough and transparent data along the global supply chain, coupled with chemical companies' ability to claim confidential business protection.[5] Tracing and accessing such data, not to mention enforcing restrictions, requires a significant investment of time and money and is often impossible under current regulatory frameworks.[4] Many companies have little incentive to seek out or evaluate information about chemicals used in their products and would face great difficulties in pursuing this information. Thus current structures facilitate rapid production and undermine the development of environmental and health data.

Consumer product companies may also struggle to gather comprehensive and reliable information about the hazards associated with replacement chemicals,

decreasing their ability and willingness to seek safer substitutes.[5] More often than not, what appears to occur is a process of "regrettable substitution" with replacement chemicals that have similar but less fully characterized exposure and toxicity profiles than the compounds they are intended to replace.[38] The process of regrettable substitution is likely occurring with highly fluorinated chemicals as well, with the widespread replacement of long-chain PFAS with short-chains. Information on potentially safer nonfluorinated alternatives and their availability is limited due to a range of factors, such as the lack of grant funding for green chemistry research and the lack of training opportunities for students in green chemistry. Green chemistry, as described by key founders Paul Anastas and John Warner, promotes the use of environmentally benign substances whenever possible; the use of renewable material feedstocks and energy sources; the use of energy-efficient processes; and avoiding the production of waste.[44] Another structural limitation is the immense financial interests behind the unencumbered use of chemicals based on their functionality.[45] Given the unique properties and functionality of PFAS that have been difficult to replicate, research and development in safer alternatives are particularly needed.

The lack of systematic development of nontoxic chemical alternatives is a prominent example of "undone science," or science that is simply not conducted or largely unfunded and frequently ignored when it is conducted, despite significant potential social and environmental benefit.[46] This "undone science" concept arises from the "new political sociology of science" (NPSS) perspective, which questions the purported objectivity and value-free nature of science, focusing on the unequal distribution of resources in scientific knowledge production to examine how rules and regulations are made, whom they benefit, and how organizations interpret such rules.[47] Undone science in the U.S. regulatory context perpetuates ignorance of potential environmental and health risk; in a system where chemicals are assumed to be safe until proven harmful, a lack of data can be characterized as a lack of harm, thus further legitimating regulatory inaction.[48]

Scientific ignorance may also be exacerbated after science is "done." Through "strategic science translation," existing science may be interpreted in different ways depending on the specific goals and interests of stakeholders.[49] In other words, PFAS chemical industry actors and others are able to present scientific evidence in ways that align with their goals. Scientific findings may also be deliberately hidden, as was the case with early research regarding the human health risks of PFOA and PFOS exposure.[9] As early as the 1980s, both 3M and DuPont had conducted internal research (including laboratory studies of primates and rodents as well as observations of factory workers) revealing potential adverse health effects of PFOA exposure, yet these results were shared only selectively with the EPA and most remained undisclosed.[50] As Richter et al. argue, this case can be conceptualized as the production of "unseen science," or research conducted but not disseminated outside of institutional boundaries and

thus not allowing for regulatory response or public attention.[50] Through such tactics, these companies were able to selectively comply with TSCA and continue to expand PFOA and PFOS production for decades. These issues remain concerning because TSCA relies greatly on industry discretion and self-reporting, while major PFAS companies have been shown to withhold or selectively disclose evidence of potential risk.[51]

Environmental Social Movements

The absence of comprehensive chemical regulation has given rise to a wide array of action within civil society to attempt to regulate and reduce toxic exposures, including a growth of consumer product markets for nontoxic goods.[52] Scholarship on market campaigns suggests that social movement action can spur shifts in the market to encourage investment in and use of alternative technologies, part of what David Hess refers to as "technology- and product-oriented movements" (TPMs).[53] The success of TPMs demonstrates how in certain contexts, social movement action can generate industrial, technological, and scientific innovation as well as influence consumption patterns, complementing the more commonly studied "industrial opposition movements" (IOMs) that aim for the cessation of particular types of technology and production practices. In the realm of social movement action on toxic chemicals regulation, IOMs that involve advocating for the elimination of chemicals already known to be harmful remain more common than advocacy aiming to spur investment in alternatives.

Nonstate targets such as corporations may be seen as particularly productive targets because of their sensitivity to image management and vulnerability to disruption.[54] Thus, environmental social movement organizations have had some success in directly confronting corporations through market-based "shame campaigns" that highlight unsustainable practices along their supply chains, threatening brand reputation, and demanding change.[55] Such public shaming techniques may be limited in their scope, however, as their leverage tends to rest on outcry over one portion of the global supply chain, seeks voluntary reform within certain companies or industries, and may be ineffective in addressing systemic issues.[56]

In some rare cases, scientific research and multi-faceted activism has converged to influence state or federal chemical policy. In response to significant media coverage, public attention, and activism by environmental health advocates and researchers, there were multiple efforts at the state and federal level to regulate certain uses of BPA.[57] The unique "multi-sector alliance" of environmental, public health, industry, and firefighting organizations working to restrict the use of flame retardants also spurred regulatory change.[56] BPA and flame retardant campaign victories illustrate the power of consumer-driven campaigns in the United States, but such instances constitute the exception rather

than the norm. Moreover, these victories were still limited to policy change for single chemicals for specific uses, rather than comprehensive regulatory reform.

Some scholars further argue that growing consumer awareness, paired with the availability of safer, "eco-friendly" consumer products, dilutes the potential for collective action needed for systemic change. Andrew Szasz refers to this phenomenon as "shopping our way to safety," wherein consumers try to protect themselves from a contaminated environment through nontoxic consumption.[58] Not only is this "inverted quarantine" largely ineffective, he argues, but it also can provide consumers with a false sense of security and can diminish the urgency of collective calls for regulatory reform. Others argue that safer consumption practices and political action may not be mutually exclusive. MacKendrick and Stevens find that individuals recognize that nontoxic consumption does not provide complete protection, and that they thus do not necessarily fall into political anesthesia.[59] Moreover, in exploring the numerous successes of the Campaign for Safe Cosmetics, Faber et al. argue that consumer-driven activism directly targeting manufacturers and retailers to phase out the use of hazardous chemicals constitutes a vital step toward more systemic chemical exposure reduction.[60]

Data and Methods

This paper is part of a broader research project tracing the social and scientific discovery of PFAS. Here, we investigate how the apparel industry has responded to a long-term Greenpeace campaign focused on pressuring clothing and outdoor gear companies to phase out the use of PFAS and adopt safe alternatives. To our knowledge, the Greenpeace Detox campaign targeting the apparel industry was the largest and most visible consumer-based campaign between 2016 and 2018 that explicitly called for full PFAS elimination; hence, it is an important case study as it represents a likely area of substantive change in the consumer goods sector.

We identified twenty-two fashion apparel and thirteen outdoor gear brands that were targeted by Greenpeace as of early 2017, the majority of which had already committed to the Detox campaign (introduced in next section). This included seven U.S.-based companies (Levi's, GAP, Columbia, PVH, L Brands, Patagonia, and Nike), one Canadian company (Arc'teryx), one Japanese company (Fast Retailing), and twenty-seven European companies (including H&M, Inditex, Mammut, Puma, and Fjallraven). We examined company websites, chemical policy documents, and any other publicly available information pertaining to PFAS use and management. In cases where information regarding chemicals or PFAS was not clearly stated and publicly available, we contacted the company directly via e-mail and phone in order to obtain chemical policy statements and records. Our final sample consisted of 105 documents, with an average of three documents per company.

We iteratively coded documents in Dedoose, a qualitative data management and analysis program that enables collaborative coding. Our coding approach had two phases: we first generated a priori codes based on broad themes of interest for our content analysis, including companies' overall approach to chemicals, their characterization of PFAS and alternatives to PFAS, and any action steps outlined or undertaken. In the second phase, we examined the corporate documents, adding new and more specific codes that emerged through the initial coding process. Two members of the research team coded a sample of documents to ensure intercoder reliability and to make necessary alterations and additions to initial codes. The rest of the documents were coded by one researcher.

Findings

Greenpeace's International Detox Campaign

In early 2011, Greenpeace International launched the Detox Campaign to tackle hazardous chemical use in the global textile and clothing industry. The campaign followed on the heels of an expository report by Greenpeace, "Dirty Laundry", that exposed links between global brands like Nike and Adidas and textile manufacturing facilities in China found to be releasing toxic chemicals into surrounding waterways.[61] Subsequent reports revealed widespread chemical contamination in clothing and footwear sold by global brands,[62] as well as how chemicals used in manufacturing are released back into waterways when consumers wash their clothes in regular washing machines.[63] Greenpeace International mobilized consumers and activists in creative actions including demonstrations in front of major clothing stores around the world and gathering thousands of signatures for petitions asking for a toxic-free future. The campaign called on major clothing companies to take Detox Commitment pledges, which would require them to aim to meet three main goals by 2020: (1) chemicals management, by way of creating a Manufacturing Restricted Substances List focused on at least 11 priority hazardous chemical groups (including PFAS) and testing wastewater discharge and sludge to ensure they are not present in production; (2) transparency in chemicals management practices, of wastewater and sludge testing results, and of supplier information; and (3) substitution and elimination of use, particularly of alkylphenol ethoxylates (APEs), PFAS, and phthalates.

In 2013, the campaign shifted its focus to the outdoor apparel sector and its heavy use of PFAS for dirt- and water-repellant technology. Two reports by Greenpeace Germany revealed high concentrations of PFAS in outdoor jackets produced by well-known brands,[64] and other reports by Greenpeace International documented the severity and ubiquity of PFAS contamination not only in the air of retail stores selling outdoor gear,[65] but also in remote mountainous areas around the world.[66] In September of 2015, Greenpeace's

organizing led thousands of consumers to contact their favorite outdoor brands through Twitter, Facebook, and e-mail, to ask, "Which of your products are made with PFAS?" Swedish brand Fjällräven responded that it had already eliminated all PFAS from its products as of 2015, and brands like Vaude and Jack Wolfskin announced goals to eliminate PFAS from products by 2020.[67] However, other major companies including Mammut, Patagonia, The North Face, Decathlon, Arcteryx, Salewa, and Haglöfs report the continued use of short-chain PFAS, citing the lack of durable and high-performance alternatives as the main reason for not eliminating all PFAS.

The outdoor apparel campaign does appear to have had some impact on the practices of suppliers to the wider outdoor industry, however. In early 2017, Gore Fabrics—perhaps the most well-known supplier of waterproofing technology—announced a commitment to eliminating "PFCs of environmental concern" from all products by 2023, after an "intense and fruitful discussion with Greenpeace."[68] The roadmap outlined an extensive research and development plan for developing nonfluorinated durable water repellent (DWR), with seven internal teams devoted to this effort. Gore Fabrics' annual report even included a quote from Chiara Campione, the Detox Outdoor Corporate Lead from Greenpeace Italy:

> Greenpeace welcomes this move as a real game changer in the outdoor industry. Given Gore Fabrics' influential role in the value chain, the innovation that Gore is driving will significantly broaden the range of materials free of hazardous PFCs for outdoor products.

Given that Gore Fabrics provides material to many outdoor companies, its research and development work into non-PFAS fabrics may have a broader market impact and could pave the way for alternative chemical production at the scale that other large companies require. However, Gore Fabrics is not eliminating PFAS as a whole class of chemicals; PTFE, for example, is explicitly treated by the company as an acceptable fluorinated chemical for continued use given that it is "not bioavailable" and thus does not meet their criteria as a "PFC of Environmental Concern" (highly fluorinated, bioavailable, and persistent).[69]

In 2013, Greenpeace International also launched the Detox Catwalk phase of the campaign to assess the varied extent of progress (or lack thereof) made by Detox committed brands. In this stage and in two more assessments in 2015 and 2016, Greenpeace ranked nineteen committed companies as "Avant-Garde" leaders, "Evolution Mode," "Faux Pas," or "Toxic Addicts" and published these results online.[70] To date, eighty fashion brands, outdoor apparel brands, retailers, and suppliers have taken up the Detox commitment, with 72% reporting that they have completely eliminated PFAS from their products.[71]

Almost all Detox committed brands practice regular wastewater testing and publicly disclose results, though such updates are also self-reported.

The overall campaign has had notable political impact in several countries. After the Detox Outdoor project, Greenpeace Italy documented PFAS contamination in the Veneto Region in Northeast Italy, publishing two reports on wastewater discharges and drinking water contamination in schools. The campaign, bolstered by the support of local residents, successfully pushed the regional government to establish a regulatory limit for PFAS in drinking water, setting a precedent for the rest of Italy. Similar efforts by Greenpeace Indonesia highlighted industrial pollution in the Citarum River linked to the textile industry and the involvement of multinational brands such as GAP. GAP refused to take responsibility or to commit to the Detox campaign, but Greenpeace Indonesia was able to pursue litigation to successfully suspend wastewater discharge permits for three major polluting textile factories. In conjunction with the Detox Campaign, Greenpeace Mexico identified Levi's as one of the main clients of two denim factories releasing various hazardous chemicals, the publicity from which likely contributed to Levi's subsequent commitment to the Detox campaign. The Mexican government also established a mandatory pollutant release and transfer regulation in 2014 and closed eleven textile factories between 2015 and 2016 for pollution violations. Greenpeace claims that the Detox campaign also helped to trigger China's enforcement of stricter wastewater standards, the EU's ban on textile imports containing nonylphenol ethoxylates to take effect in 2020, and proposed EU regulation on carcinogenic substances in textiles.[71]

A 2018 report by Greenpeace International summarizing the overall progress of the Detox Campaign outlined persistent broader challenges, as described by Detox-committed companies.[71] Clothing brands cited the difficulty of supply chain management and the lack of transparency from chemical suppliers, especially from small local suppliers, and the challenge of dealing with cross-contamination and unintentionally added substances and impurities. Companies also reported gaps in knowledge and information about safer alternatives, pointing to higher costs, inferior performance, or lack of availability. Such issues have arisen most notably among outdoor gear and sportswear brands, which largely continue to rely on PFAS for "high performance" applications. Importantly, they highlight a lack of support from local and national regulatory bodies.

Corporate Characterization of PFAS

Of the thirty-five companies we examined, fifteen claim to have phased out PFAS as a class of chemicals, and another seven companies claim to be on a timeline to do so by 2020. Only two out of the seven U.S. companies included in our analysis phased out PFAS as a class of chemicals (or even committed to doing so), and just twelve out of twenty-seven European companies have done

so. There was a relative consensus regarding the harmful nature of long-chain PFAS; twenty-three companies included language along these lines. "Science has shown that long-chain C8 PFCs can be hazardous in very high concentrations; they are toxic and suspected to be carcinogenic," read one document from the outdoor company Salewa.[72] By contrast, only a handful of companies specifically addressed concerns surrounding short-chain PFAS. For example, Fast Retailing stated that "although short-chain PFCs show less environmental and human health impact than long-chain PFCs, they may also be substances of concern."[73]

Outdoor gear and sportswear companies widely emphasized the functionality and durability of PFAS in justifying continued use of short-chain PFAS. As stated by outdoor brand Vaude in a 2015 document,

> good outdoor clothing must be water and dirt repellant to provide the necessary protection in all weather conditions. To achieve this functionality, chemical substances are used. Poly- and perfluorinated chemicals (PFCs) play an important role in the manufacturing of outdoor gear.[74]

Interestingly, Vaude has since successfully phased out all use of PFAS, as discussed below. Swedish outdoor brand Haglofs explained that while they have phased out the use of long-chain PFAS, "some products, where high performance may be the difference between success and fatal error, however, still use a C6-DWR technology (with lower environmental impact) to meet the high-performance demand of our customers."[75] Sportswear company PUMA framed the continued use of short-chain PFAS as progressive and environmentally conscious; in a 2013 statement, PUMA announced that it would phase out all use of long-chain perfluorinated chemicals, and that "all products manufactured from 2015 onwards [would] use more environmentally friendly technologies based on short-chain repellent or alternative chemistries."[76]

Four companies further highlighted scientific uncertainties surrounding the extent to which wearing PFAS-treated clothing actually leads to potentially harmful exposure, and defended their use of these chemicals. In their company blog, for example, Mammut explicitly stated that "the PFC treatments used in the outdoor sector are harmless to human health"; citing a 2012 document published by the German Federal Institute for Risk Assessment, the company claimed that "the average daily absorption of PFCs through textiles is far below the value accepted as the threshold for toxicological effects."[77] In addition to ignoring the uncertainties underlying these types of risk assessments and multiple sources of daily PFAS exposure via other routes, such logic privileges the health of consumers while disregarding impacts on the health of workers and fence-line communities along the global supply chain. We bring this up because it is generalizable to many other consumer campaigns around toxics in food and products, where the health impact on workers is often disregarded.

In a somewhat gentler defense, Patagonia stated, "we are not aware of information linking skin contact from the routine use of apparel to an uptake of fluorochemicals into the human body and any potential for harm."[78] They went on to clarify, however, that because of their concern for the persistence of these chemicals in the environment, they were seeking alternatives to PFOS and PFOA. Interestingly, two other companies—Salewa and Vaude—added that even though users of outdoor products may not be harmed, other processes including the manufacturing, washing of the finished products, and disposal can lead to groundwater contamination and thus pose a threat to humans, animals, and the environment along the supply chain. Yet overall, the acknowledgement of potential harm to human health along the supply chain was rare.

Characterization of Alternatives to PFAS

Thirteen companies explicitly stated that functionally equivalent alternatives to PFAS exist, and these companies already have such alternatives in use. The German fashion brand Espirit, for example, clearly stated that "many global chemical suppliers offer PFC-free chemicals in their portfolios of products to achieve water, dirt, soil and oil repellent surfaces on textiles."[79] Only four out of these thirteen companies are outdoor brands, with the rest focused on everyday apparel with less demand for water-repellent technology. More commonly, alternatives to PFAS are framed as inferior or not as functional. For example, despite already having alternatives in use, the fashion company Primark stated that "the PFC-free alternative is currently slightly more expensive and provides good water repellency," but that "it does not provide oil repellent effects like the PFOA-based chemical."[80] In describing their transition to alternative Durable Water Repellent technology based on short-chain PFAS, the outdoor clothing company Arc'teryx warned consumers of the potential shortcomings in product performance and durability of PFAS-free alternatives.[81] Ironically, transitioning to less functional alternatives can also be framed as a tradeoff in environmental impact. Norrona, the Norwegian outdoor clothing and sporting gear brand, sells clothing and jackets treated with PFAS-free technology, but implied that this may decrease the lifespan of their products:

> Norrona is of the opinion that the highest quality and long lifetime are essential to reduce the environmental footprint of our products. It is better that you use a jacket for several years than buy a new one every year.[82]

Five companies explicitly stated that functionally equivalent alternatives do not exist, and an additional six companies stated that PFAS are "necessary" to ensure high quality and consumer safety. This is particularly the case for companies promoting high-performance sporting and outdoor gear that consumers can use even in extreme conditions. For example, the outdoor clothing and gear

company Salewa framed itself as a "technical mountaineering brand" whose "first responsibility is user safety"; stated that by 2020 it would "replace C6 with non-PFC alternatives for all apparel products *except where it is necessary* (the highest performance range)" (emphasis added).[72] Mammut similarly announced that it aimed to treat all clothing with PFC-free alternatives by 2020, "with the exception of the core segment, where absolute water protection and complete breathability have safety implications."[77] Sportswear company Adidas adopted a somewhat defensive tone in responding to Greenpeace's 2012 report calling for Detox Commitments, again presenting the notion that PFAS are irreplaceable: "based on current scientific knowledge, the level of functionality and durability of certain finishes cannot be reached with PFC-free solutions."[83]

Yet the claim that functionally equivalent chemicals do not exist is suspect, given several companies succeeded in phasing out the use of all PFAS. This includes small European brands like Fjällräven, Paramo, Radys, Rotauf, and Pyua that have long been producing PFAS-free, high-performance outdoor gear meant to withstand high altitude, extreme-weather conditions. Fjällräven even sells PFAS-free waterproofing spray for use on shell garments, as well as a ten-dollar bar of wax made of paraffin and beeswax that customers can apply to garments to enhance wind and water resistance. While there may be difficulty in scaling up the production and use of such alternative technologies, larger outdoor gear companies like Vaude (a German brand) have also succeeded in developing waterproof sporting gear with PFAS-free alternatives. Many of their products now bear an "Eco Finish" label, meaning that they have been waterproofed with a range of PFAS-free alternatives from various vendors.[84] Their most recent sustainability report pointed out that oil repellency is the one function that can still only be provided by PFAS technology, but that this function may not even be necessary; "we have thoroughly examined this issue of whether outdoor products really need this feature and decided that for Vaude, they do not—for the planet and for all of us."[85] Vaude's logic provides a useful yet rare contradiction to the claims of the Fluorocouncil[7] and numerous companies that the features provided by PFAS technology are indispensable.

Barriers to Substantive Change

Environmental social movements have increasingly moved beyond opposing certain industries and technologies, to spurring the development of safe and viable alternative technologies and products.[53] In the context of campaigns against PFAS, however, rarely have companies responded by investing in alternative innovation. In one unique example, Patagonia invested heavily in a small but growing Swiss company called Beyond Surface Technologies (BST), through its "$20 Million & Change" fund, launched to support innovative companies developing sustainable methods of production.[86] BST's product line focuses

on water and oil repellant protection, with one product explicitly listed as PFAS-free. The company has also partnered with Levi's and Adidas. In the meantime, however, Patagonia still uses DWR technology based on a short-chain C6 treatment.

Two companies described involvement in research collaborations aimed at identifying alternatives to PFAS technology. Since 2013, for example, Swedish outdoor brand Haglofs has been part of a major research project spearheaded by three universities and corporate stakeholders with the goal of developing PFAS alternatives.[87] Seven other companies mentioned pursuing internal research on viable alternatives to PFAS that are already on the market. For example, German clothing company Espirit described pursuing extensive research on PFAS alternatives, eventually identifying eleven alternative chemicals that would meet the requirements of the Detox Commitment and the Manufacturing Restricted Substances List of the ZDHC Group.[79] The chemicals were tested at Espirit's own laboratory in Germany, where Greenpeace staff also visited to evaluate the testing methods and procedures. Espirit further claimed to be working with certified external laboratories to check that the alternative chemicals in use are not harmful.

Furthermore, information on chemical hazards along the supply chain can be inconsistent, nonexistent, or protected by trade secrets (or confidential business information claims), creating another barrier to substantive change.[5] Product manufacturers and retailers further the challenge of knowing exactly what substances are present in products, as PFAS can occur as byproducts or contaminants of other commercial products. Levi Strauss & Co., for example, sources from about 630 facilities in forty-three countries worldwide, and thus the company's commitment to phase out hazardous chemicals requires the sizable task of monitoring the compliance of all suppliers.[88] Hence, in order to meet the Detox campaign's demands for increased transparency surrounding chemical management, several companies mentioned conducting independent water testing at production factories. Companies like Valentino, Mango, and Primark have conducted waste water sampling from supplier factories in countries including China, India, Turkey, and Bangladesh in order to identify the use of priority chemicals in the manufacturing process. In a 2015 report, Mango reported that PFAS had not been detected in tested factory wastewater in Bangladesh, but that they had been detected in Turkey.[89] Perhaps more fundamentally, PFAS chemical manufacturers are unlikely to fully disclose the often trade secret-protected chemical mixtures that they sell, so factories and retail companies may not know what new PFAS compounds to test for.

Similar inconsistencies in product testing results reveal the difficulty that companies face in preventing unintentional use of PFAS. In a 2016 Detox Commitment update, fashion company Valentino reported that the frequency of PFAS detection in raw materials and finished products had decreased significantly; in a July–September 2015 testing of seventy items, 17% were found with

PFAS, while only 9% of 298 items tested between October 2015 and March 2016 were found with PFAS. The report explained, "we can see that the percentage of failed test for leather and synthetic materials has decreased thanks to the work of awareness and case studies done following the previous test campaign indications."[90] Other companies acknowledged the possibility of accidental contamination as almost inevitable; Columbia's new line of Outdry Extreme Eco PFC-free waterproof jackets served as a case in point. "No PFCs intentionally used in these jackets," the description read, followed by the parenthetical disclaimer, "(may contain trace amounts)."[91] Such examples shed light on the notion that companies themselves may not always be fully aware of all the chemicals being used in their products. Yet supply chain complexity also opens up room for companies to distance themselves from responsibility for chemical contamination of products.

Overall, fashion and outdoor clothing manufacturing companies have little incentive to pursue or invest in nonfluorinated chemical development, especially given that short-chain PFAS are categorized as safe substitutes under current chemical statutes. Voluntary schemes require companies to independently research and assess chemical safety and to develop technologies to improve product safety; as Scruggs et al.[5] point out, this is highly inefficient and incomplete.

Discussion and Conclusion

Most U.S. consumers assume that chemicals are well regulated, and that the ingredients in their consumer products are known to be safe for human health.[38] In publicizing product-testing results through shame campaigns and informative reports, environmental advocacy groups alert consumers that such assumptions may be misguided, and that certain risks associated with everyday products warrant concern. This case study demonstrates the strength of civil society actors in generating change in the private sector, particularly when their efforts involve a globally coordinated and long-term campaign drawing on pressure from consumers, as with the Greenpeace Detox campaign. As consumers, we certainly cannot "shop our way to safety,"[58] but perhaps "organizing our way to safety" alongside environmental advocacy groups constitutes a significant step toward more sustained structural change; consumer-driven campaigns are valuable in fueling broader awareness and activism around the issue of toxic chemicals and thus are an important component of the broader movement toward industry and policy reform.[60]

However, it has proven challenging for advocates to take meaningful action toward reducing use of the class of PFAS. Voluntary commitments by companies to reduce the use of or replace PFAS also do not ensure compliance, accountability, or the assurance that companies have chosen nontoxic alternative chemicals. Global commodity chains involve multiple regulatory regimes, and thus companies may face barriers in implementing chemical policy changes

across the supply chain. Moreover, there is no guarantee that the average consumer will be able or willing to partake in environmentally conscious purchasing, particularly if that means potentially paying a higher price for a lower performance item. Finally, broader environmental and social justice concerns remain unaddressed; these actions may protect wealthier consumers situated primarily in the Global North, rather than the many people along the global supply chain who are involved with continued manufacturing of PFAS and those who live near contaminated production sites.[92] While the production of PFOS, PFOA, and similar long-chain chemicals have largely ceased in the United States and Europe, short-chains are produced in multiple U.S. facilities, and additional production of both long- and short-chain chemicals has shifted to China and Southeast Asia.[93] This case study reveals that activism and incremental corporate changes may produce a false sense of security for consumers as well as an illusion of progress when the global production of this class of chemicals remains unaffected.

Without regulatory power, advocacy groups are limited to seeking voluntary pledges by companies to make piecemeal changes. Stricter and more precautionary chemical regulation on a federal level could mandate or incentivize innovation among both chemical and product manufacturers, bolstering green chemistry and usher safer alternatives onto the market.[94] Federal regulations would also ideally require more rigorous documentation of activities along the supply chain, mandate up-front chemical testing, as well as better disclosure of product ingredients. Increased public and corporate funding of academic or independent research centers devoted to green chemistry, and closer collaborations between such actors, also constitute important steps in spurring more innovation in nontoxic alternatives.

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