ENVIRONMENTAL POLICY

Plastic bag bans and fees reduce harmful bag litter on shorelines

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Plastic pollution threatens marine and freshwater ecosystems and the services they provide. Although plastic bag bans and taxes are increasingly implemented worldwide, their effectiveness in reducing plastic litter remains unknown. Leveraging the patchwork of bag policies across different geographic scales in the United States and citizen science data on 45,067 shoreline cleanups, we assess the impact of these policies on plastic bag litter. We find that plastic bag policies lead to a 25 to 47% decrease in plastic bags as a share of total items collected at cleanups relative to areas without policies, with taxes possibly further reducing shoreline litter. At a time when many jurisdictions are considering bag policies, while others are preemptively prohibiting them, our study provides evidence that they mitigate shoreline plastic pollution.

Plastics have become ubiquitous across the planet, with plastic debris now constituting the majority of marine litter worldwide (*1*–*5*). This widespread pollution poses major threats to marine animals and ecosystems (*6*). Marine plastics may be ingested, leading to fatal digestive system blockages; cause animal entanglement, suffocation, or injury; and release toxic chemicals into the ocean, causing considerable economic and social damages through their adverse effects on various ecosystem services (*7*). Plastic litter on shorelines can also negatively affect tourism and waterfront property values (*8*). According to some estimates, the global social costs associated with damages from plastics to marine natural capital exceed USD 100 billion per year (*9*). Although the literature has focused on marine plastics, recent studies highlight detrimental impacts on freshwater ecosystems as well (*10*). Addressing the problem is becoming a global policy priority: More than 100 countries have national or subnational policies regulating plastic carrier bags (*11*), and 175 countries are in talks to create the first global plastics treaty (*12*).

The vast majority of plastic debris found in the ocean is believed to come from land sources, primarily as a result of waste mismanagement. Most mismanaged plastic waste reaches the oceans through rivers, but plastic can also arrive via wastewater discharge and wind or tidal transport (*13*, *14*). Previous studies have modeled the fate of plastics and the flow of the material from land to the ocean (*15*–*17*). Approximately 2 to 5% of generated plastic waste worldwide is estimated to enter the oceans annually, with local variation driven by population size and quality of waste management (*16*). A global survey of 12 million marine litter items found that plastic bags were the most common, accounting for 14% of all items (*18*).

Single-use plastic shopping bags are common objects with notoriously low recycling rates that are easily caught and transported by winds. Both command-and-control approaches (such as outright plastic bag bans) and economic incentives (such as fees or taxes on bags) are growing in popularity around the world. These include a variety of state and local bag policies in the United States, which is estimated to be the 20th-largest direct contributor to marine debris (*16*). Bag policy proponents often cite the effects of plastics on aquatic ecosystems (e.g., animal entanglement) as reasons to regulate single-use plastic materials. However, there has been only anecdotal evidence that plastic bag policies may be reducing plastic litter (*19*).

Observational studies using point-of-sale scanner data find that select local US plastic bag policies decrease disposable, thin plastic bag consumption at grocery checkouts (*20*–*22*). However, the same studies find a substitution toward consumption of paper, reusable bags, and thicker plastic bags, especially in the case of narrowly defined bans (e.g., bans that only prohibit thin plastic bags) (*20*, *22*). For this reason, fees (taxes) on bags appear to be more effective in reducing total bag consumption. Internationally, evidence on the effectiveness of bag fees is mixed. Whereas policies in England, Scotland, Wales, and Buenos Aires have led to reductions in bag use (*23*, *24*), and policies in Taiwan have decreased waste and recycling (*25*), South Africa's bag fee resulted in only temporary declines in plastic bag consumption (*26*).

What these studies have not answered is how these effects on plastic bag consumption translate to the policies' underlying goal of reducing plastic litter, particularly in shoreline and aquatic environments. This depends on how the policies affect both consumption and waste management. For example, a plastic bag policy could fail to reduce plastic consumption because of substitution with thicker bags [in the case of a partial ban (*20*)] or unregulated bags, such as restaurant takeout bags or purchased garbage bags (*27*). Yet a plastic bag policy could still reduce plastic bag litter in the environment if it turns out the substituted bags are more likely to be reused or recycled, less likely to fly away in the wind, or less likely to disrupt waste management by jamming recycling machines (*28*). Only a few pathways illustrating how plastic policies influence the movement of plastic bags, from consumption through waste management to environmental litter, are documented in the literature (fig. S1). Reports and papers with summary statistics of plastic litter before and after bag policy implementation do not control for litter trends over time and are often looking at the effects of a single policy with small sample sizes (*19*).

Literature has highlighted the need to more systematically evaluate whether plastic bag policies are positively affecting the marine environment (*29*). This research gap is becoming increasingly important as 175 countries attempt to negotiate the first international treaty on plastics, following a commitment in 2022 at the United Nations Environment Assembly (*12*). The question has also come up in legislative analyses of US state-level bills that would prohibit local regulation of plastic bags (*30*), known as "preemption" laws. As of September 2024, 17 US states have passed full preemption laws that prohibit their counties and towns from regulating plastic bags.

We fill this knowledge gap by leveraging data on tens of thousands of shoreline cleanups and hundreds of local policies to provide causal evidence on market-based and command-and-control policies' roles in reducing plastic litter in the environment. We first compile data on 611 town-, county-, and state-level plastic bag policies and categorize them according to policy characteristics. This allows us to estimate descriptive statistics on the reach of plastic bag policies. We then use crowdsourced data on 45,067 shoreline cleanups from January 2016 to December 2023 to circumvent the usual challenges of measuring plastic pollution. Although shoreline cleanups do not capture all aquatic litter, they offer a proxy for the prevalence of various litter types, including plastic bags. There were 182 policies implemented from January 2017 to December 2023, a period we selected to begin 1 year after our cleanup data for control purposes (see materials section in the supplementary materials for more details on the data collection and cleaning). We leverage the rollout of plastic bag policies across the US and implement various difference-in-differences estimators robust to heterogeneous treatment effects (*31*–*34*) to identify the causal effects of plastic bag policies on plastic litter in the environment. These estimators allow us to control for the share of plastic bag litter prior

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