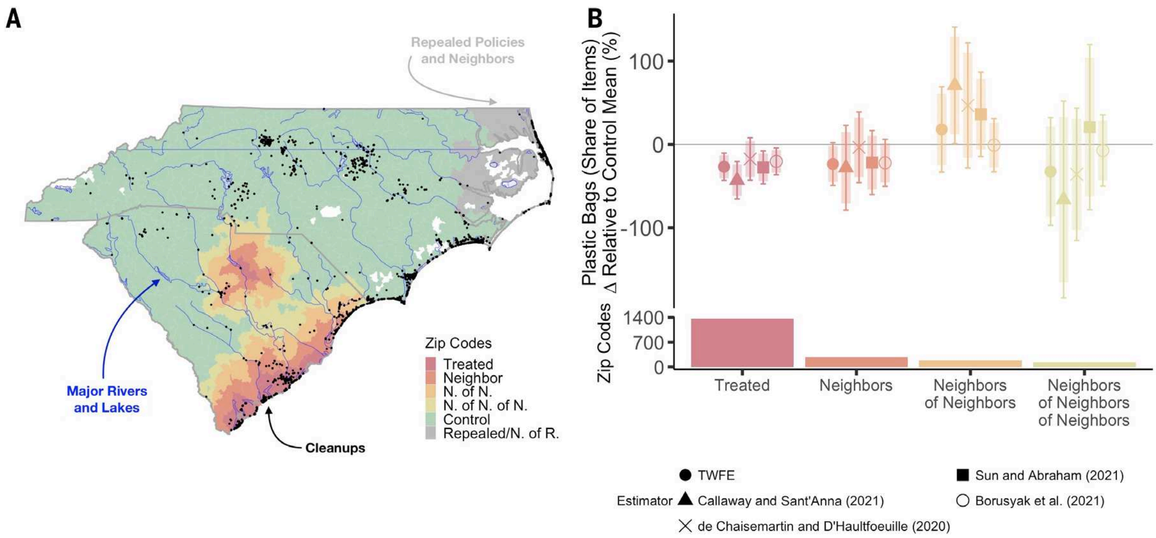

Fig. 3. Spillover analysis. (**A**) South and North Carolina zip codes are used to illustrate the spillover definitions. The zip codes' colors represent treatment category: treated zip codes with bag policies, zip codes neighboring these policies, neighbors of neighbors (N. of N.), neighbors of neighbors of neighbors (N. of N. of N.), and control zip codes. Zip codes whose policies were repealed and their neighbors, neighbors of neighbors, and neighbors of neighbors of neighbors are all in gray. (**B**) Panel shows the effect of bag policies on plastic bag litter across these treatment groups, for all of the United States. Regression outcomes are according to eq. S1 using five estimators [TWFE and (*31*–*34*)] and using the zip code by year aggregation level. Zip codes with repealed policies (and all neighbors) are dropped from the analysis. The outcome variables are plastic bags' share of total items collected on shoreline cleanups documented in TIDES, divided by the control mean. Thick lines show a 90% confidence interval, and thin lines show a 95% confidence interval. Standard errors are clustered by zip code.

much larger for fee-based policies (Fig. 4A). As there are fewer policies with fees, our estimates of the effect of these policies have larger confidence intervals, so the differences in the magnitude of effects between these policies are only suggestive. It is also worth noting that several of the fee-based policies are in landlocked zip codes whose shorelines are along rivers and lakes (fig. S2). Partial bans show the smallest and least precise effects, perhaps owing to exceptions for thicker plastic bags.

We then study the effects of policies at different geographic scales and separate state, county, and town-level policies. We find that all geographic scales of policy are effective, with state-level policies being the most robust (Fig. 4B). In general, we observe relative declines in plastic litter across most of the eight coastal states that have implemented bag policies between 2017 and 2023 (fig. S13).

We also explore effects across different types of water bodies. Whereas bag policies had similar effects along coasts and rivers, there is suggestive evidence that they had larger effects along lakes (Fig. 4C). This may be due to the fact that litter along lake shorelines is less likely to spill over into neighboring areas than is litter along coasts and rivers (see "Spillover analysis"). While these estimates are larger in magnitude, they are also noisier because of the smaller sample size. Additionally, we break out results by connection and proximity to oceans, including results for cleanups within 10 km of coasts and those in watersheds that drain to oceans (fig. S14). Finally, we explore whether bag policies have larger effects on places with more litter before policy enactment (fig. S15) and find that they do. In fact, most of our results are driven by places that had higher shares of plastic bag litter before the policy (Fig. 4D). These are areas where plastic bags make up 13.2% of items collected, on average, and are in the 75th percentile or above in share of plastic bag litter. Bag policies appear to show no effect on areas that already had low shares of plastic bag litter. However, we cannot disentangle whether this is because consumer behavior did not change as a result of the policy, these areas have better waste management, or these areas have land cleanups before litter reaches shorelines.

Effects on wildlife entanglement

Although plastic bags make up a small percentage of shoreline litter at any point in time, plastic's long life cycle allows it to accumulate in the ocean over time. The coastal cleanup data provide counts of entangled animals found along the shoreline. We find an imprecise 30 to 37% reduction in the presence of entangled animals due to plastic bag policies in comparison to places without policies, using an unbalanced panel of data on entanglements (Fig. 5A). These estimates are noisy because plastic bags are not the only cause of animal entanglement. How plastic bags, other shoreline litter, and wildlife interact is not well understood. Results are larger and statistically significant for some but not all estimators using a balanced panel (Fig. 5B). We find an imprecise reduction in entanglements using a conditional logit model (table S5) and using the number of entangled animals as an outcome variable (fig. S16). This result suggests that plastic bag policies may be reducing animal entanglement, but we cannot rule out the possibility of a null effect. Further data and research are needed to confirm these findings and understand the broader ecological impacts on aquatic ecosystems.

Discussion

Our findings make clear that plastic bag policies have been broadly effective in limiting—but not eliminating—shoreline plastic bag debris in jurisdictions where it was previously prevalent. There is also suggestive evidence that fees may have a greater impact than bans, especially partial bans, although further research is needed to understand why. If we assume that the sample used in our analysis is representative of all plastic bag litter in the US aquatic environment, then increasing the prevalence of plastic bag bans or fees would continue to decrease plastic bag litter and potentially wildlife entanglement compared with business as usual. The external validity of these results, including outside the US, would depend on how different consumption and waste management are from our sample. For example, parts of Africa are estimated to have 12 times more uncollected or mismanaged plastic waste than the United States (*13*). This suggests that the impact