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In a Nutshell. . .

MICROPLASTICS

Kicking pellet emissions to the curb. Tsui et al.

A status update and recommended solutions for reducing the environmental release of microplastics pellets, a major source of plastics contaminating aquatic systems.

SPECIES CONSERVATION MEASURES

How to make voluntary species conservation work for pesticide registrations. Brain et al.

A showcase of some new pilot projects intended to demonstrate the feasibility and utility of species-specific conservation measures in support of pesticide registrations. The approach is shown to benefit both landowners and listed species.

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KICKING PELLET EMISSIONS TO THE CURB

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In 2018, 348 million metric tons of plastic resin was produced globally (PlasticsEurope 2018). This plastic resin, which occurs in the form of pellets, flakes, and powders, is incorporated into plastic products for consumer markets. Resin manufacturing, conversion, molding into familiar products, recycling, and transportation by land and sea, are all part of a multibillion dollar industry. Improper maintenance, handling, and containment cause an estimated 0.04% of resin loss to the environment annually (Sundt et al. 2014), accounting for approximately 139 000 metric tons globally, or the loss of US$144 million based on a $1/kg commodity price.

This loss of materials results in environmental contamination, from local watersheds to distant marine ecosystems. Such contamination has been reported for decades, including in wildlife and remote locations far from where the materials are produced and used. Moreover, this has occurred despite industry commitments to achieve zero pellet losses through voluntary best practice programs, such as Operation Clean Sweep (OCS). In fact, plastic contamination trends have increased with rates of production and use since the 1960s. This trend is expected to continue unless loss prevention plans and practices are effectively implemented.

PREPRODUCTION PLASTIC PELLETS ARE ONE SOURCE OF MICROPLASTIC POLLUTION

Here, we highlight one microplastics source—preproduction pellets—demonstrating their contamination and suggesting possible solutions. Still, many sources of plastics in the local and global environment are recognized. For microplastics specifically (i.e., plastics <5mm in size), the sources include: personal care products, laundering of clothing, tire wear particles, industrial materials, and fragmentation of larger plastics over time (Eerkes-Medrano et al. 2015).

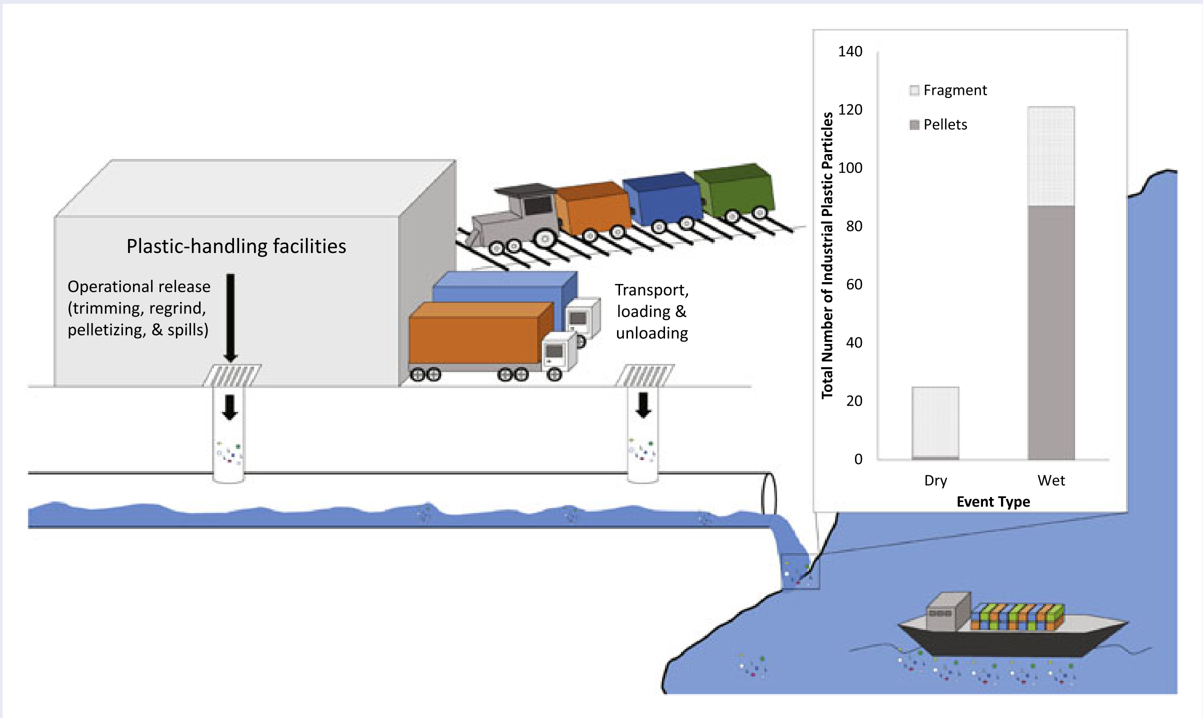

Figure 1. Sources and fate of industrial microplastics. Facility operations, transport, and transfer processes can directly release pellets and waste fragments into stormwater channels, sewers, and waterways. The inset chart highlights microplastics data collected in a freshwater stream from June to August 2019.

Preproduction pellets have been frequently reported as plastic debris items around the Great Lakes (Zbyszewski et al. 2014). Intending to translate locally relevant results to local industries, we examined pellet loss in a Great Lakes tributary that is 98% urbanized. This tributary, leading into Lake Ontario, receives runoff from 18 plastics-based companies in its 77 km^2 watershed (according to listings in ThomasNet [2019]). Using a 368 μm mesh net, we collected 3 wet- and 4 dry-weather flow grab samples downstream of industrial discharges from June to August 2019. The captured microplastics particles were sieved into 1 to 5 mm size fractions, identified under a microscope, counted, and categorized (e.g., pellets, fragments, foam, rubber, film, or spheres). A subsample (i.e., 10% of the total samples) was analyzed via Fourier transform infrared spectroscopy (FTIR) to confirm visual identification and assess polymer types.

Our primary interest was pellets and industrially-characterized fragments as signatures of plastics industry losses. For these 2 categories, 146 industrial microplastic particles (i.e., 88 pellets and 58 fragments [Figure 1]) were collected from a total of 890 particles, most of which were collected during wet weather (i.e., 99% of pellets and 59% of fragments). The concentrations of pellets and fragments ranged from 0.06 to 43 particles/m−3, and all particles selected for FTIR analysis were confirmed to be synthetic—71% polyethylene, 22% polypropylene, and 3% polystyrene. This exemplifies how stormwater locally transports materials from plastics facilities into the environment and is consistent with contamination reports in the Great Lakes region, Canada, North America, and globally.

PREVENTING PELLET AND RESIN EMISSIONS AT SOURCE

The G7 Ocean Plastics Charter, signed in 2018, pledges to identify microplastic contamination sources and "prevent leakage of plastics into the marine environment from all sources" (ECCC 2018). In Canada, a Strategy on Zero Plastic Waste is being developed. The industry has recognized its stewardship role in preventing pellets and product losses, with 47 plastics industry associations around the world signing a declaration to find marine litter solutions. As part of efforts to address marine litter, plastic industry associations promote OCS, an example of an environmental management system in which companies implement voluntary best management practices to achieve zero pellet loss. Of the 60 000 facilities operating in Europe, only 500 are pledged to OCS, indicating that a voluntary approach alone may not sufficiently ensure the broad adoption of the program. This low participation trend extends to the local Lake Ontario watershed, where only 3 of the 18 companies within its boundaries had pledged to OCS. The only regulatory action specific to preproduction pellets we know of is in California (i.e., Assembly Bill 258), which regulates commercial facility discharge. Based on decades of contamination, we suggest that broader-scale initiatives are warranted to enhance the adoption of best management practices at all relevant facilities.

We suggest an approach that is not foreign to other industries with environmental emissions: interception at the source. For example, food service establishments

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install grease traps to prevent fats, oils, and grease from entering pipes (USEPA 2012). Similarly, facilities storing petroleum above ground or underground, such as gas stations, are also required to install oil-water separators to prevent fuel release into the environment (USEPA 2013). Likewise, facilities handling microplastics and producing microplastics debris should undertake actions that ensure plastics are isolated and captured before any facility discharges enter local watersheds, lakes, and oceans. One method for solving this issue may be installing low-cost catch basin filters near pellet transfer and storage locations, grinding operations, etcetera, thereby preventing pellets and plastics debris from being swept into stormwater drains. For example, a New Zealand-based company, Medical Plastics, which uses such a filter (i.e., LittaTrap), successfully prevented annual losses of an estimated 220 000 pellets. These filters provide companies with a feasible solution to "backstop" microplastics emissions into waterways, while they work to prevent losses and spills caused by operating procedures.

Using simple, easy-to-implement solutions provides opportunities for businesses to further direct their efforts toward greater stewardship, the prevention of plastics emissions into the environment, and any associated cleanup and operational costs. Businesses and governments can collaborate to enhance the implementation of best management practices, document success stories with data, and provide momentum for larger-scale changes. Implementing interception at the source could divert billions to trillions of pellets from the environment, thereby ensuring that they stay within their industries where they belong.

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HOW TO MAKE VOLUNTARY SPECIES CONSERVATION WORK FOR PESTICIDE REGISTRATIONS

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For decades, potential impacts to threatened and endangered ("listed") species from oil, gas, forestry, and mining industry sectors have been successfully addressed, in many cases through avoidance, minimization, and offset measures tailored to those species (Arlidge et al. 2018). Could those types of measures also apply to pesticides? In concept, yes, but generally, the potential impacts posed by pesticide uses are far more spatially diffuse, temporally variable, and ecologically dynamic in comparison to those posed by the aforementioned industries, which tend to be more discrete and tractable in nature. Not surprisingly, from a purely geospatial perspective, the footprint of the collective ranges for all 1012 currently listed species in the conterminous United States (of the total 1678 listed species), overlaps with US "cropland" area in its entirety, highlighting the scope of the issue (Figure 1A). Necessarily, applying species-specific conservation measures to pesticides will require new policies and processes (Heinen 1995); however, given the current challenges of evaluating potential pesticide risks as required under Section 7 of the Endangered Species Act (ESA 1973), species-specific measures are an approach worth pursuing.

Such a conservation approach is currently being piloted among a partnership of local landowners, several grower associations, federal agencies, and a manufacturer of agrochemicals (participants are listed in the *Acknowledgment* section). The goal of the partnership is to advance

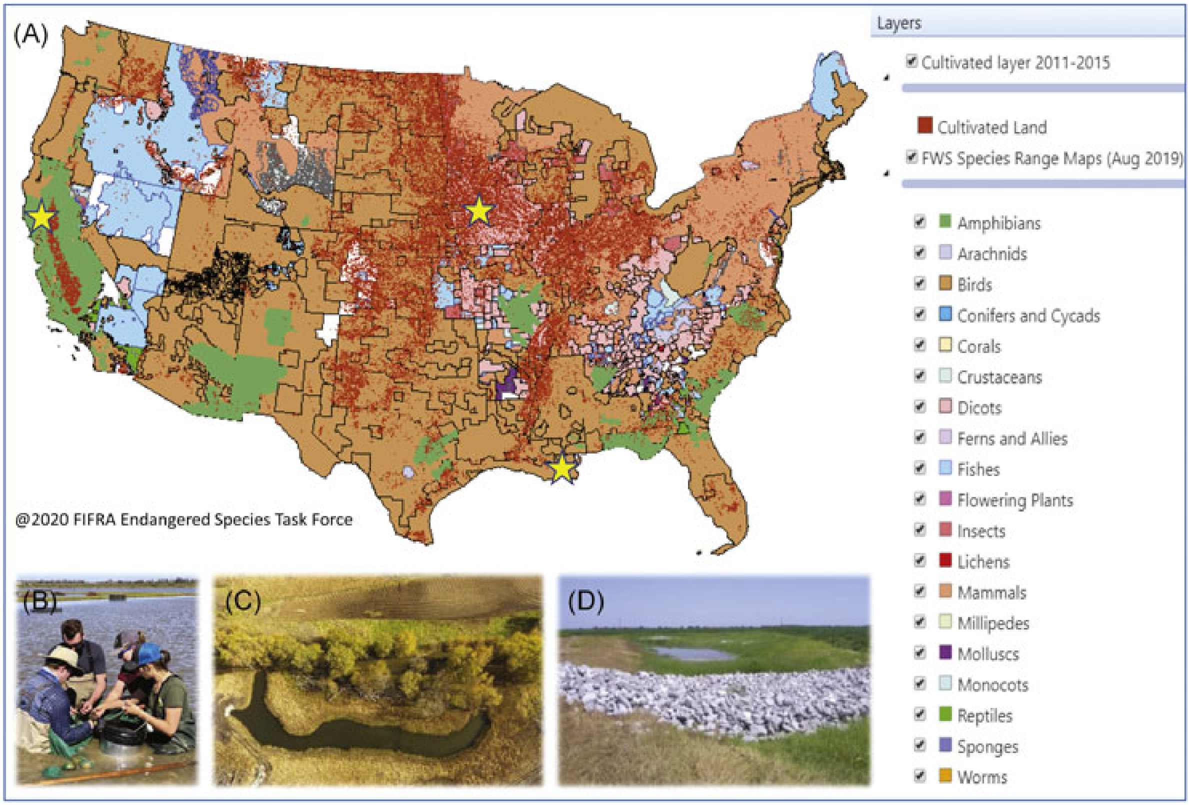

Figure 1. Geospatial overlay of federally listed (threatened and endangered) species range relative to cultivated cropland in the conterminous United States generated using the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Endangered Species Task Force (FESTF) GOPHER tool (**A**) and examples of pilot species conservation efforts, including tagging fish in a rice paddy in California (**B**), completion of an off-channel oxbow in Iowa (**C**), and installation of a low-grade weir to prevent sediment loading from runoff in Mississippi (**D**); locations indicated with stars.

conservation efforts (e.g., habitat establishment, restoration and development of on-farm conservation plans consisting of best management practices to address water quality, irrigation management, pesticide application, and listed species education) in Mississippi, Iowa, and California for several listed species, including the pondberry, fat pocketbook mussel, rabbitsfoot mussel, Topeka shiner, rusty patched bumble bee, and Chinook salmon. These pilot projects are intended to demonstrate the feasibility and utility of species-specific conservation measures, benefiting both landowners and listed species (Figures 1B, 1C, and 1D). Although challenges pertaining to scaling, implementation, monitoring, and other issues remain, to date the collective stakeholder engagement and effort is a good start.

Programmatically, how would species-specific conservation work for pesticide risk evaluations? First, the potential risks of pesticides to listed species would need to be identified accurately and realistically, so that it is clear which conservation measures are needed. Second, stake-holder engagement would need to be pragmatic, local, diverse, and collectively focused on harmonizing listed-species protection with agricultural production. Third, the outcomes of the conservation measures would need to be measurable, transparent, and documented. Moreover, for species-specific conservation to work on or proximal to America's farmlands, a mechanism for incentivizing grower participation would be necessary.

For species-specific conservation to be viable, implementable, and effective for pesticides, corresponding "risks" to species in question need to be defined as accurately as possible. If risk predictions are too coarse, the result will likely be a proliferation of Type I errors, or false positive effects on species (Brain et al. 2015), making it infeasible to target conservation measures where risks may exist. Pipelines, forestry, mining, and many infrastructure projects are often able to avoid this problem because their footprint is better defined by being geographically explicit. Without accurate and explicit definition of potential risks, imprecision and subjectivity could undermine implementation. In particular, improved range maps for ESA-protected species to more precisely define where species are likely to occur (USFWS 2019) are necessary. For example, the current county-level resolution maps for many species are inadequate for applying species-specific conservation measures to pesticides. At the same time, better information pertaining to where and when

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pesticides are applied is also necessary. With better species maps and pesticide usage data, pesticide risk assessments will improve considerably. The compliance costs of registration reside with the agricultural chemical industry. Therefore, associated monetary investment in species conservation necessitates accurate and realistic evaluation of potential risks in order to properly align compensation with risk responsibility.

Successful implementation of a species conservation approach for pesticides also requires balanced and fair input from a diverse group of stakeholders. The survival and recovery of listed species is the primary consideration under the ESA, but agricultural production in the face of a shrinking agricultural landscape (i.e., producing more from less) should also be considered in broader government policy decisions. In addition to government and industry, nongovernmental organizations (NGOs) can play an important role in implementing and advocating for conservation efforts. Moreover, growers and landowners also need to be represented as the primary stewards of the land and as the ultimate administrators of conservation measures agreed to as part of an ESA decision. Removing land from agricultural use reduces production and profit, and thus incentivizing conservation is essential, further emphasizing the need for accurate risk evaluation.

If you cannot implement something, it is just a concept, and if you cannot measure something, it did not happen, at least perceptually. Thus, it is fundamental that the benefits from species conservation measures be measurable, but by whom? The US Fish and Wildlife Service and National Marine Fisheries Service ("the Services") have primary responsibility for conserving ESA-listed species, including the tracking of overall species' conservation status. But on a project-by-project basis, the project proponent (e.g., pesticide registrant) is responsible for implementing and monitoring the outcomes of conservation measures (USFWS 2016). That responsibility, however, can be delegated or transferred to a third party, such as a conservation bank or in-lieu-fee program. The latter provides a form of compensatory mitigation, involving funds paid to a governmental or nonprofit organization for the purposes of habitat restoration, establishment, enhancement, and/or preservation (Fox and Nino-Murcia 2005). Thus, the ESA allows permittee-responsible mitigation, in-lieu-fee mitigation, and conservation banking to help offset the potential adverse effects of federal actions evaluated through an ESA Section 7 consultation, if those effects cannot be adequately addressed through avoidance and minimization measures.

Approximately 40% of the United States is farmland that is held in a diversity of landownership types (e.g., property ownership, leases, rentals). To facilitate access to, and participation among, those landowners, a broader landowner credit marketplace may be necessary to complement conventional mitigation approaches. Whatever form the conservation mitigation takes, it needs to be transparent and documented. The financial burden of conservation measures should not reside with farmers and ranchers; rather, they should be incentivized as essential partners. Another important question is, "Who would carry out the actual physical improvement, maintenance, or creation of listed-species habitat?" Questions like these should be addressed in guidance that the Services develop specifically to deal with the complexities of ESA pesticide evaluations and conservation measures. It is strongly recommended that such guidance be finalized in 2020.

Despite the many questions that need to be resolved, a path forward for species-specific conservation is feasible and necessary to create a workable ESA Section 7 consultation program for pesticides. Major steps to creating a workable program include an accurate and realistic risk assessment process, improved species range maps and pesticide usage data, engagement of a range of stakeholders, and establishment of monetary incentives for landowners to implement conservation measures.

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