5 GYRES
SCIENCE TO SOLUTIONS

PLASTICULTURE: SCIENCE TO INFORM SOLUTIONS

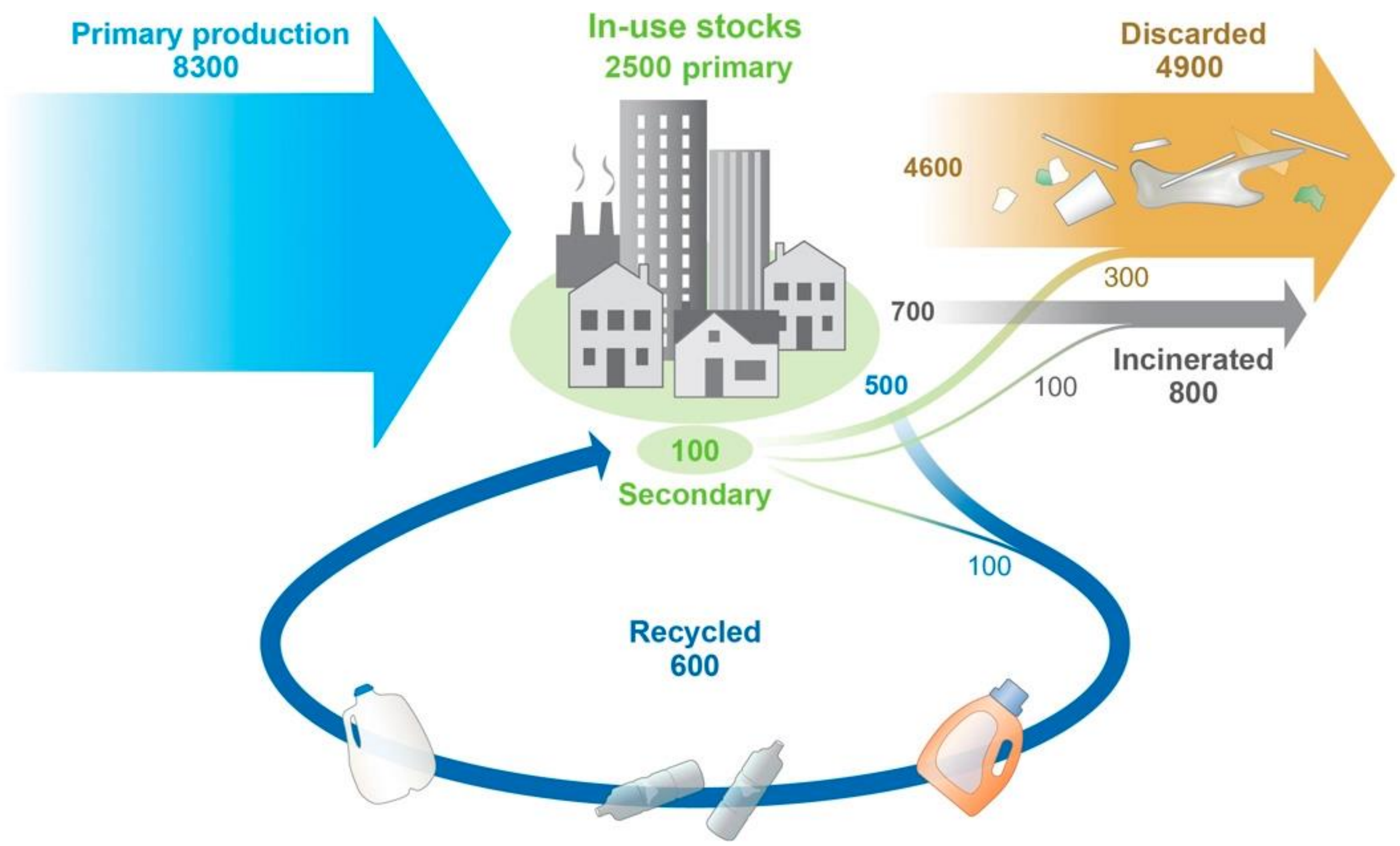
Lisa Erdle, PhD
Director of Science
5 Gyres Institute

Confluences Conference

OUR MISSION

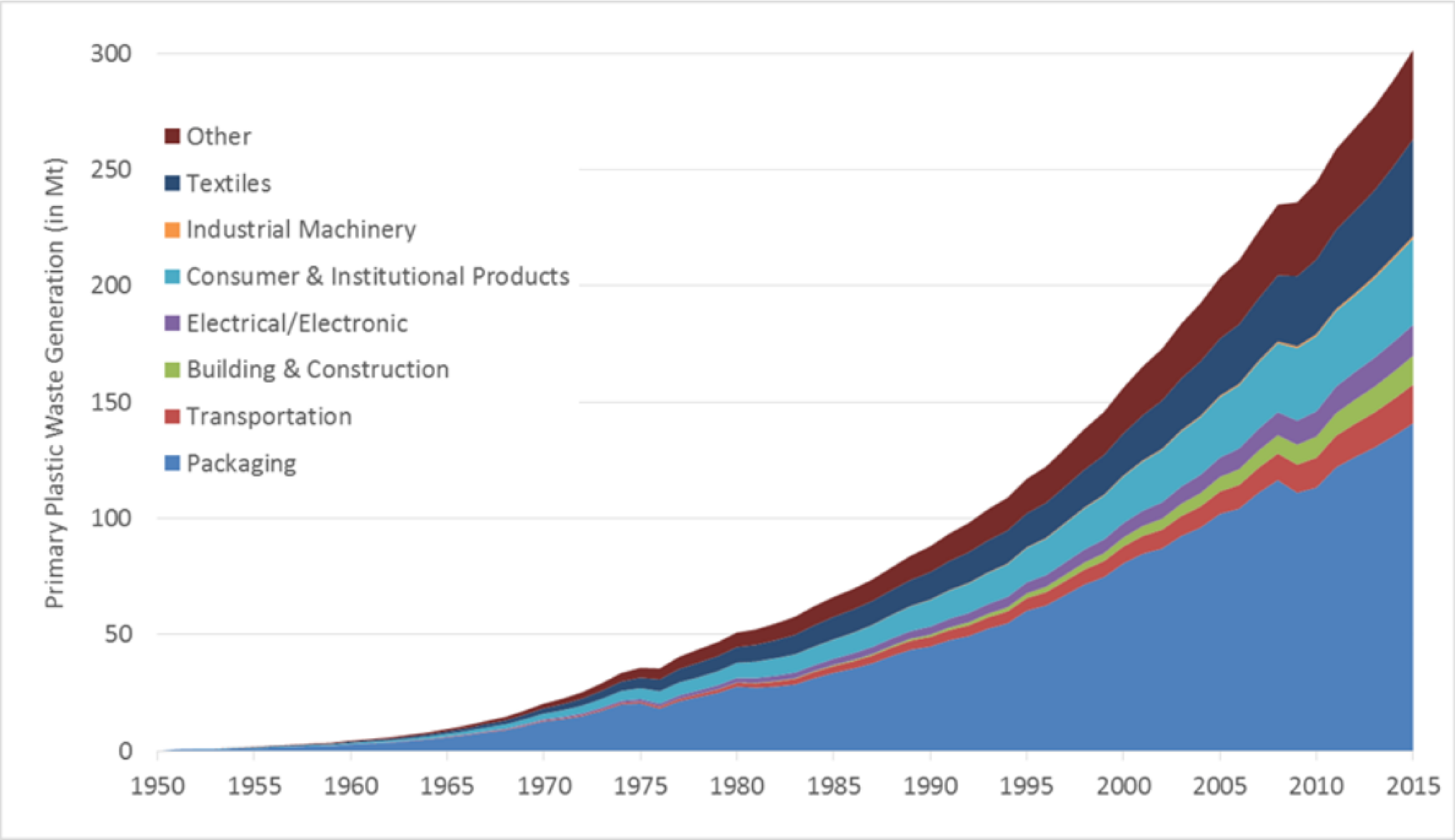
empower action against the global health crisis of plastic pollution through **science**, **education**, and **advocacy**

>50% PLASTIC PRODUCED HAS BEEN DISCARDED



GEYER ET AL. 2017, *SCIENCE ADVANCES*

PLASTIC WASTE FROM MANY SECTORS



GEYER ET AL. 2017, *SCIENCE ADVANCES*

FLOATING ISLAND OF TRASH?

- 5 Gyres Founded in 2009 to answer questions about plastic pollution
- Led 19 research expeditions to all five subtropical gyres and many of the world's lakes and rivers
- Published research on sources, fate and effects of microplastics

MACROPLASTIC

DIAMETER ≥ 5 MM

Plastic waste that is easily visible.

MICROPLASTIC

DIAMETER 100 NM - 5 MM

Small particles of plastic, often formed from the breakdown of larger plastic items.

NANOPLASTIC

DIAMETER 1 - 100 NM

Challenging to observe in the environment.

ET&C
FOCUS

Focus articles are part of a regular series intended to sharpen understanding of current and emerging topics of interest to the scientific community.

Environmental Toxicology and Chemistry—Volume 38, Number 4—pp. 703–711, 2019

Rethinking Microplastics as a Diverse Contaminant Suite

Chelsea M. Rochman,[a,*,1] Cole Brookson,[a,1] Jacqueline Bikker,[a,1] Natasha Djuric,[a,1] Arielle Earn,[a,1] Kennedy Bucci,[a,1]
Samantha Athey,[b,1] Aimee Huntington,[a,1] Hayley McIlwraith,[a,1] Keenan Munno,[a,1] Hannah De Frond,[a,1] Anna Kolomijeca,[a,1]
Lisa Erdle,[a,1] Jelena Grbic,[a,1] Malak Bayoumi,[a,1] Stephanie B. Borrelle,[a,c,1] Tina Wu,[a,1] Samantha Santoro,[a,1]
Larissa M. Werbowski,[a,1] Xia Zhu,[a,1] Rachel K. Giles,[a,1] Bonnie M. Hamilton,[a,1] Clara Thaysen,[a,1] Ashima Kaura,[a,1]
Natasha Klasios,[a,1] Lauren Ead,[a,1] Joel Kim,[a,1] Cassandra Sherlock,[a,1] Annissa Ho,[a,1] and Charlotte Hung[a,1]

Polymer
PP
LDPE
HDPE
PVC
PU
PET
PS
ABS
PMMA
POM
PBT
PC
PA
SAN
PEEK
PSU
PU
...

Additives
Plasticizers
Colorants
Reinforcements
Fillers
Flame retardants
Stabilizers
...

Product types
Primary
Pre-production pellets
Personal care products
Industrial abrasives...
Secondary
Agricultural materials
Beverage bottles
Carry bags
Construction materials
Containers
Clothing
Cutlery
Electronics
Food packaging
Film
Furniture
Insulation
Mattresses
Medical
Pillows
Pipes
Textiles
Toys
Tires
...

Size
<5mm
...
Nano
...

Morphology
Fiber
Fiber bundle
Fragment
Sphere
Pellet
Film
Foam
...

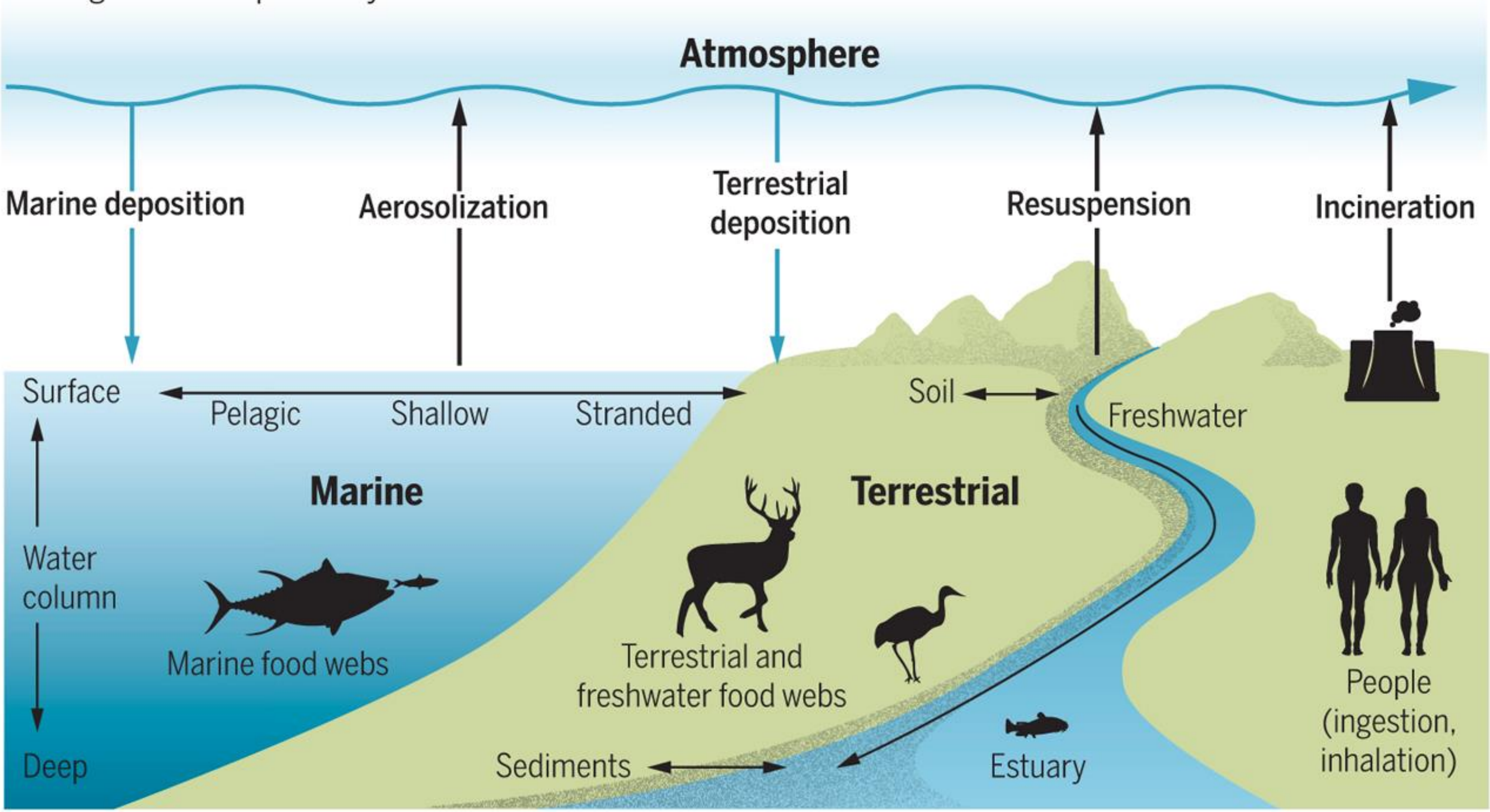
Colour
Red
Orange
Yellow
Tan
Brown
Off white
White
Grey
Blue
Green
...

Eco-toxins
PAHs
PCBs
DDT
Heavy metals
PBDEs
...

ROCHMAN ET AL. 2019, *ET&C*

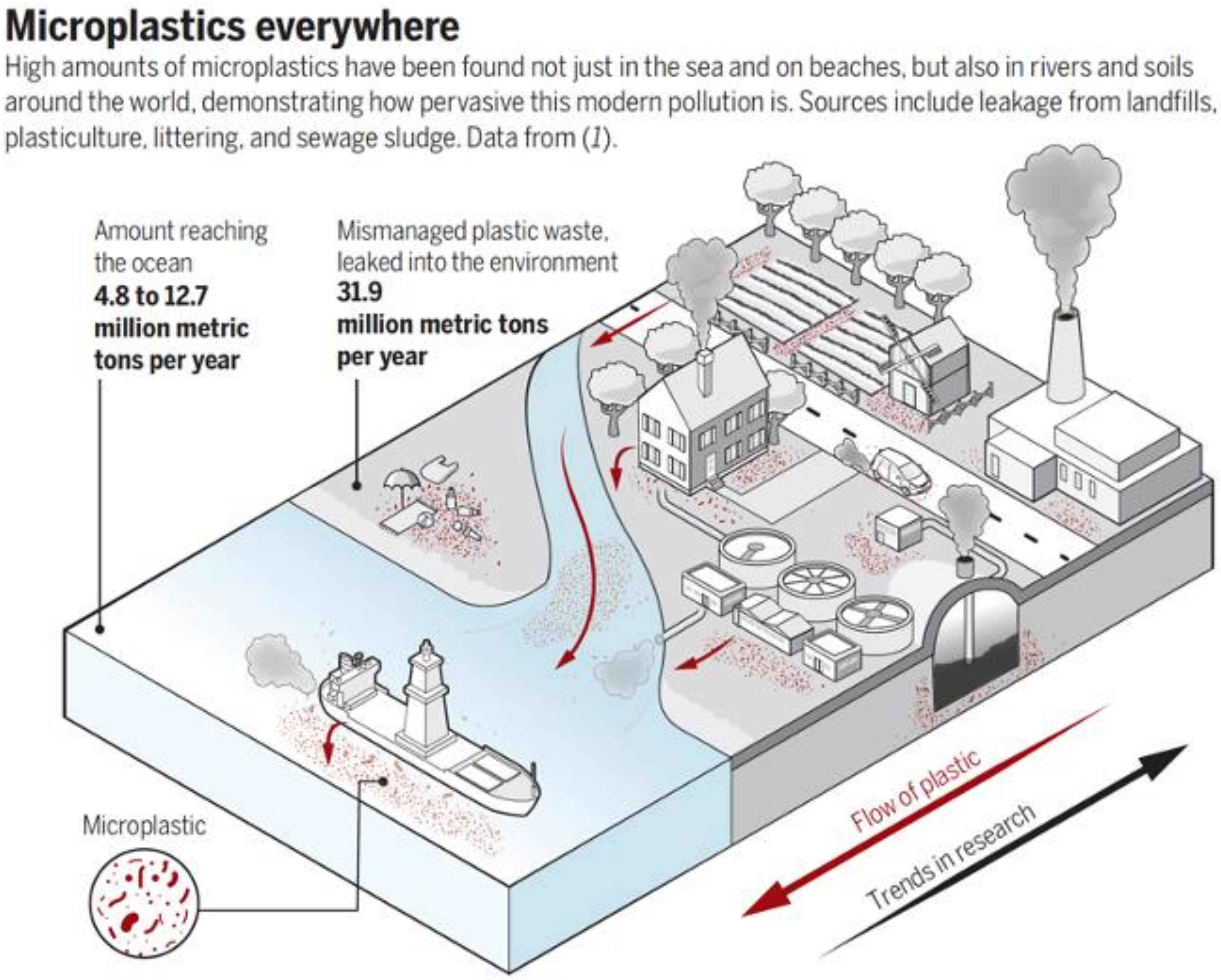
Microplastic pollution is pervasive

Emerging research pinpoints atmospheric deposition as a mode of microplastic transfer to the western United States. Mapping microplastic pools (water, land, organisms) and fluxes (arrows) will guide delineation of the global microplastic cycle.

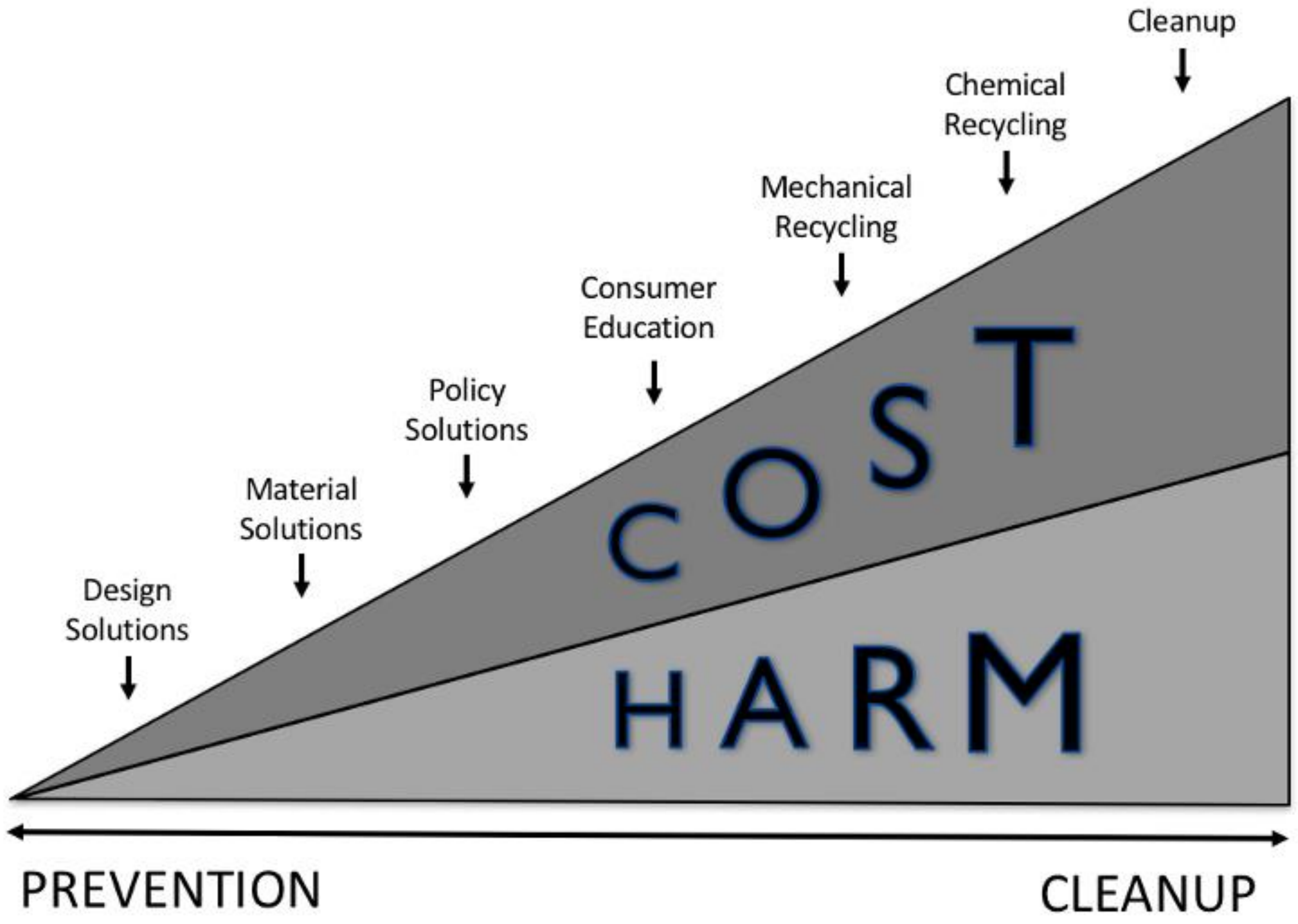


GOING UPSTREAM

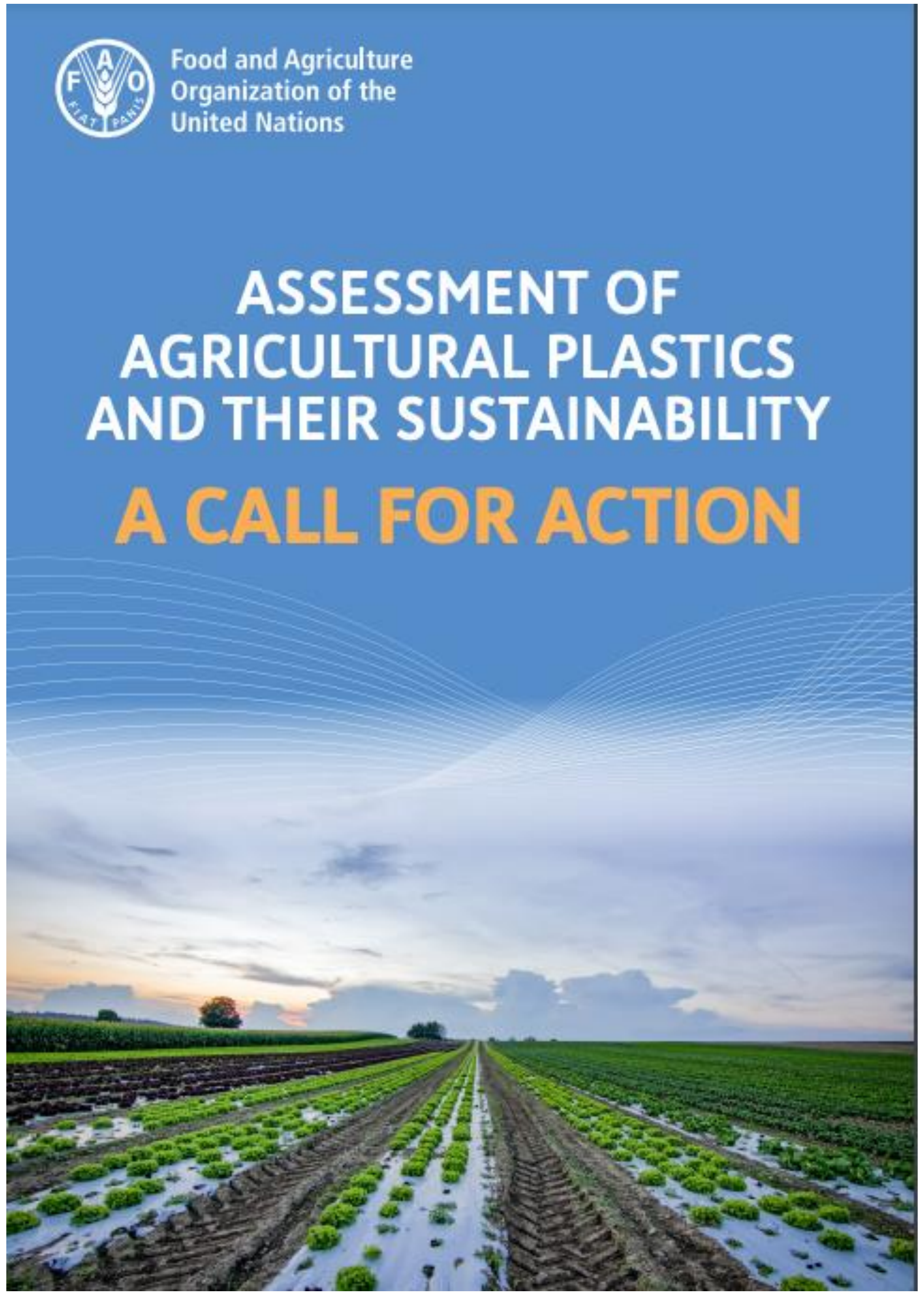
- Shift from an ocean focus to address problem from the source
- Full lifecycle of plastic, from extraction to disposal



SOLUTIONS WILL VARY BY SECTOR



SOLUTIONS NEEDED FOR AGRICULTURE



FAO, 2022

Agricultural activity or phase	Propagation		Cultivation											Feed production			Animal care		Fisheries and aquaculture			
DECISION-MAKING CRITERIA	Greenhouse films	Pesticide containers	Mulching films	Fertilizer containers – bags and rigid	Plant pots, seedling plugs	Tree guards	Plastic bags (bananas)	Plastic ties, ropes, twines	Polymer coated slow release fertilizer	Crates for harvesting	Irrigation tubes and drips (semi-permanent)	Irrigation drip tape (single-use, on-soil applications)	Pond liners	Silage films	Bale films and nets	Bale twine	Ear tags	Bags for feed	Fishing nets and ropes	Net float	Cages	EPS boxes
SOURCE (what are the products and how they are used)																						
Extent of usage - how much is used	3	3	3	3	3	1	3	1	3	1	2	3	1	2	3	1	2	2	3	3	3	2
Turnover factor (number of applications/year)	0,3	5,0	2,0	2,0	3,0	0,3	1,3	3,0	4	1	0,5	2	0,3	0,5	2	2,2	1,2	3,4	0,4	0,4	0,4	6
Normalized SUM	1,65	4,00	2,50	2,50	3,00	0,65	2,15	2,00	3,50	1,00	1,25	2,50	0,65	1,25	2,50	1,60	1,60	2,70	1,70	1,70	1,70	4,00
PATHWAY (how it enters the environment – 3Ds)																						
Potential for leakage into the environment at site of use:																						
Damaged	2	1	3	1	2	3	3	3	3	1	2	3	2	2	3	3	2	1	3	3	3	2
Degraded	1	2	3	2	2	2	3	3	3	1	1	3	1	2	3	3	2	2	3	3	3	2
Discarded	1	2	3	2	2	1	2	2	3	1	2	3	3	2	3	3	1	2	3	3	3	1
Potential for leakage from site of use/application (diffusion into wider environment)	3	1	2	1	1	2	2	1	3	1	1	2	1	1	2	1	1	1	3	3	3	2
Normalized SUM	1,75	1,50	2,75	1,50	1,75	2,00	2,50	2,25	3,00	1,00	1,50	2,75	1,75	1,75	2,75	2,50	1,50	1,50	3,00	3,00	3,00	1,75
RECEPTOR (primarily where it ends up)																						
Extent of direct contact with terrestrial environments	1	2	3	2	2	3	2	2	3	1	3	3	3	2	2	2	1	2	1	1	1	1
Extent of direct contact with aquatic environments	1	2	1	2	1	1	1	1	2	1	1	1	3	1	1	1	1	1	3	3	3	2
Normalized SUM	1,00	2,00	2,00	2,00	1,50	2,00	1,50	1,50	2,50	1,00	2,00	2,00	3,00	1,50	1,50	1,50	1,00	1,50	2,00	2,00	2,00	1,50
CONSEQUENCE (harm it causes once it has reached the receptor)																						
Potential to harm plants (crops & loss of productivity)	3	1	3	2	1	1	3	1	1	1	1	1	1	3	3	1	1	2	1	1	1	1
Potential to harm animals (livestock, domestic & wild)	3	3	3	2	2	2	3	3	1	1	1	2	1	3	3	3	1	2	3	2	3	2
Potential to harm humans	1	3	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
Potential to form microplastics	2	1	3	2	2	3	2	2	3	1	1	1	1	2	3	2	1	2	3	3	3	3
Normalized SUM	2,25	2,00	2,50	1,75	1,50	1,75	2,50	1,75	1,50	1,00	1,00	1,50	1,00	2,25	2,50	1,75	1,00	1,75	2,00	1,75	2,00	1,75
RISK TOTAL – Normalized	6,7	9,5	9,8	7,8	7,8	6,4	8,7	7,5	10,5	4,0	5,8	8,8	6,4	6,8	9,3	7,4	5,1	7,5	8,7	8,5	8,7	9,0

Agricultural activity or phase	Propagation		Cultivation											Feed production			Animal care		Fisheries and aquaculture			
DECISION-MAKING CRITERIA	Greenhouse films	Pesticide containers	Mulching films	Fertilizer containers – bags and rigid	Plant pots, seedling plugs	Tree guards	Plastic bags (bananas)	Plastic ties, ropes, twines	Polymer coated slow release fertilizer	Crates for harvesting	Irrigation tubes and drips (semi-permanent)	Irrigation drip tape (single-use, on-soil applications)	Pond liners	Silage films	Bale films and nets	Bale twine	Ear tags	Bags for feed	Fishing nets and ropes	Net float	Cages	EPS boxes
SOURCE (what are the products and how they are used)																						
Extent of usage - how much is used	3	3	3	3	3	1	3	1	3	1	2	3	1	2	3	1	2	2	3	3	3	2
Turnover factor (number of applications/year)	0,3	5,0	2,0	2,0	3,0	0,3	1,3	3,0	4	1	0,5	2	0,3	0,5	2	2,2	1,2	3,4	0,4	0,4	0,4	6
Normalized SUM	1,65	4,00	2,50	2,50	3,00	0,65	2,15	2,00	3,50	1,00	1,25	2,50	0,65	1,25	2,50	1,60	1,60	2,70	1,70	1,70	1,70	4,00
PATHWAY (how it enters the environment – 3Ds)																						
Potential for leakage into the environment at site of use:																						
Damaged	2	1	3	1	2	3	3	3	3	1	2	3	2	2	3	3	2	1	3	3	3	2
Degraded	1	2	3	2	2	2	3	3	3	1	1	3	1	2	3	3	2	2	3	3	3	2
Discarded	1	2	3	2	2	1	2	2	3	1	2	3	3	2	3	3	1	2	3	3	3	1
Potential for leakage from site of use/application (diffusion into wider environment)	3	1	2	1	1	2	2	1	3	1	1	2	1	1	2	1	1	1	3	3	3	2
Normalized SUM	1,75	1,50	2,75	1,50	1,75	2,00	2,50	2,25	3,00	1,00	1,50	2,75	1,75	1,75	2,75	2,50	1,50	1,50	3,00	3,00	3,00	1,75

FAO, 2022

Agricultural activity or phase	Propagation		Cultivation											Feed production			Animal care		Fisheries and aquaculture			
DECISION-MAKING CRITERIA	Greenhouse films	Pesticide containers	Mulching films	Fertilizer containers – bags and rigid	Plant pots, seedling plugs	Tree guards	Plastic bags (bananas)	Plastic ties, ropes, twines	Polymer coated slow release fertilizer	Crates for harvesting	Irrigation tubes and drips (semi-permanent)	Irrigation drip tape (single-use, on-soil applications)	Pond liners	Silage films	Bale films and nets	Bale twine	Ear tags	Bags for feed	Fishing nets and ropes	Net float	Cages	EPS boxes
RECEPTOR (primarily where it ends up)																						
Extent of direct contact with terrestrial environments	1	2	3	2	2	3	2	2	3	1	3	3	3	2	2	2	1	2	1	1	1	1
Extent of direct contact with aquatic environments	1	2	1	2	1	1	1	1	2	1	1	1	3	1	1	1	1	1	3	3	3	2
Normalized SUM	1,00	2,00	2,00	2,00	1,50	2,00	1,50	1,50	2,50	1,00	2,00	2,00	3,00	1,50	1,50	1,50	1,00	1,50	2,00	2,00	2,00	1,50
CONSEQUENCE (harm it causes once it has reached the receptor)																						
Potential to harm plants (crops & loss of productivity)	3	1	3	2	1	1	3	1	1	1	1	1	1	3	3	1	1	2	1	1	1	1
Potential to harm animals (livestock, domestic & wild)	3	3	3	2	2	2	3	3	1	1	1	2	1	3	3	3	1	2	3	2	3	2
Potential to harm humans	1	3	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
Potential to form microplastics	2	1	3	2	2	3	2	2	3	1	1	1	1	2	3	2	1	2	3	3	3	3
Normalized SUM	2,25	2,00	2,50	1,75	1,50	1,75	2,50	1,75	1,50	1,00	1,00	1,50	1,00	2,25	2,50	1,75	1,00	1,75	2,00	1,75	2,00	1,75
RISK TOTAL – Normalized	6,7	9,5	9,8	7,8	7,8	6,4	8,7	7,5	10,5	4,0	5,8	8,8	6,4	6,8	9,3	7,4	5,1	7,5	8,7	8,5	8,7	9,0

FAO, 2022

NO ONE-SIZE FITS ALL SOLUTION

MATERIAL REDESIGN

BANS

IMPROVED WASTE MANAGEMENT

MATERIAL REDESIGN: BIOMATERIALS

New report will be published this May

BIODEGRADABLE PLASTICS

- Biodegradation mainly driven by microorganisms

(Shabina et al., 2015; Bano et al., 2017)

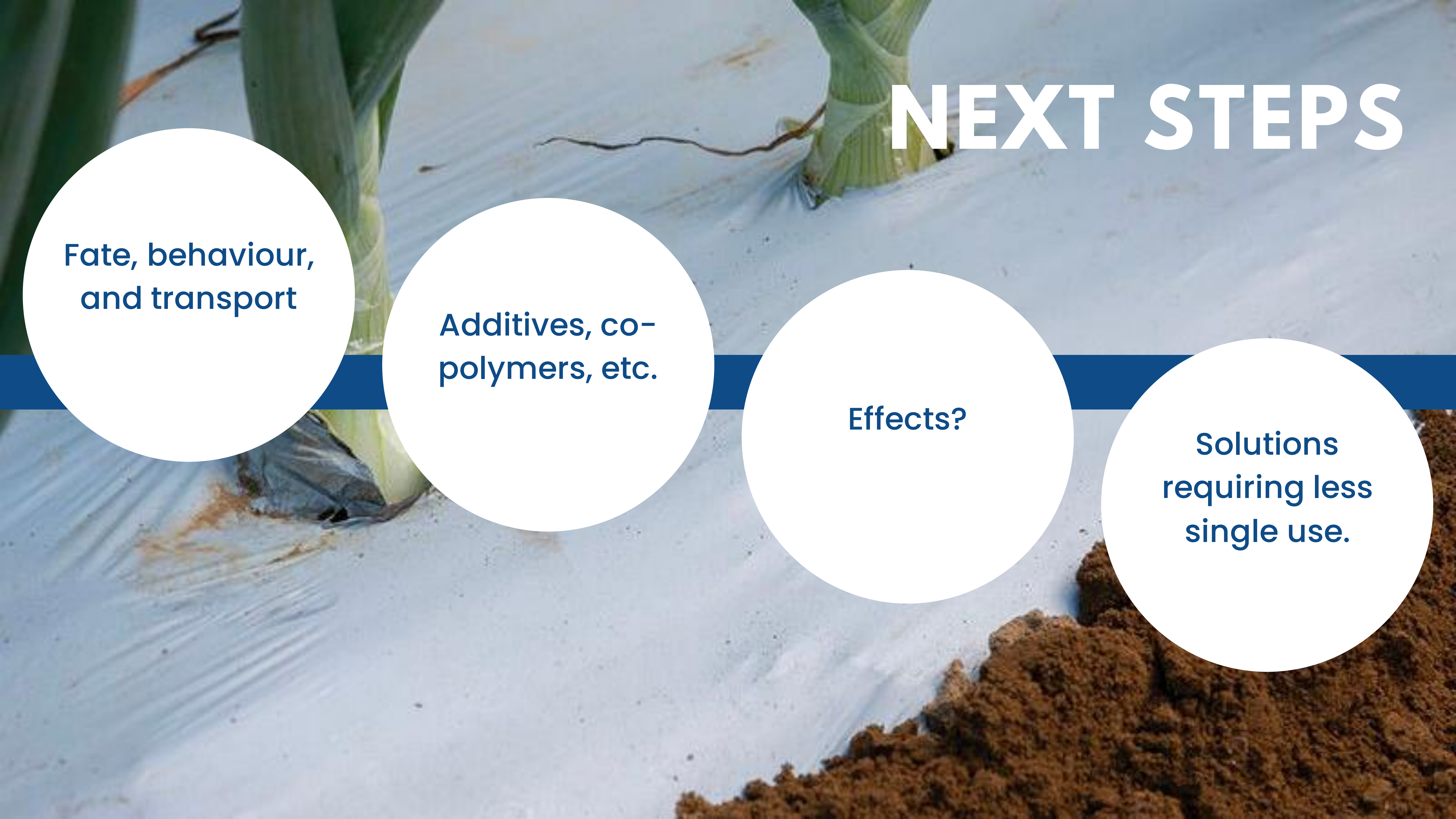
- Global interest in biodegradable plastics

(Ghosh and Jones, 2021)

How does material type and habitat impact biodegradation?

BETTER ALTERNATIVES REPORT (2017)

(SNEAK PEEK) RESULTS


NEXT STEPS
Fate, behaviour, and transport
Additives, co-polymers, etc.
Effects?
Solutions requiring less single use.

QUESTIONS?

THANK YOU!

Lisa Erdle
Director of Science & Innovation
lisa@5gyres.org

Ben Von Wong, October 2021
“Giant Plastic Tap”