

Plastic entering the ocean between 1990-2015

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How much plastic entered the ocean 1990-2015?

1) How much **plastic waste** is produced?

- How much waste is generated?
- What fraction of the waste is plastic?

2) How much is **mismanaged**?

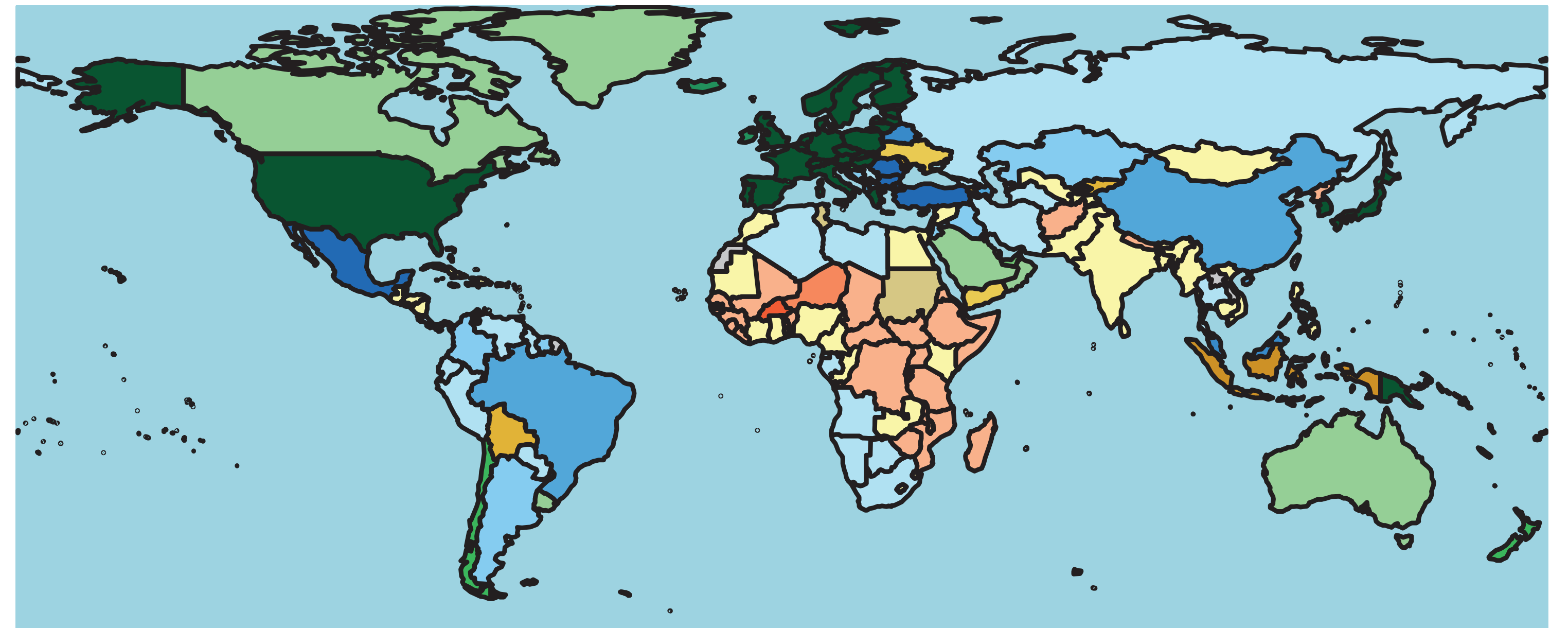
3) How much **enters the ocean**?



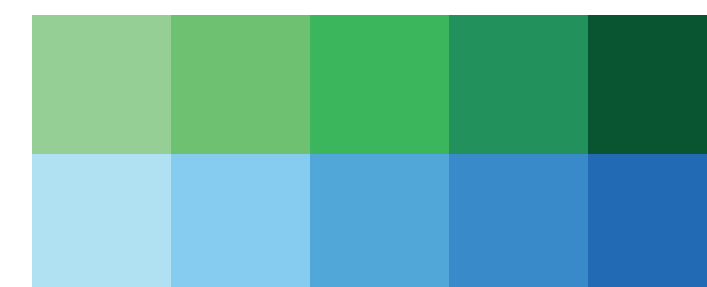
Available waste generation data (on country level)

2015: Waste generation, composition and management for most countries
(*World Bank, Kaza et al. 2018*)

1990 - 2015:
Waste collected at households for some countries/years (1432 data points out of 3200)
(*United Nations*)



Income class and number of available years No data



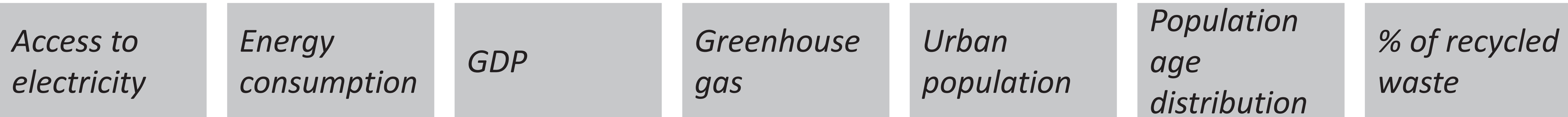
<5 10 15 20 25



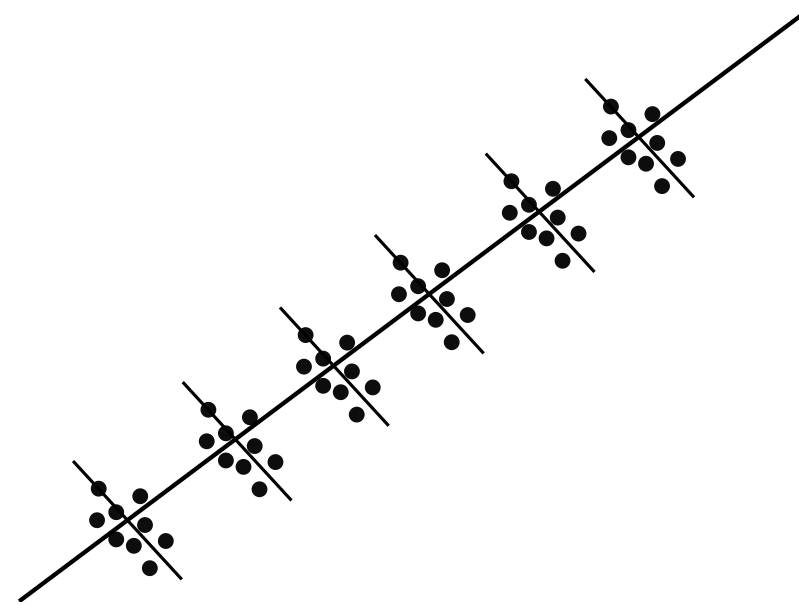
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Approach: Machine learning to get waste generation for each country and each year 1990-2015

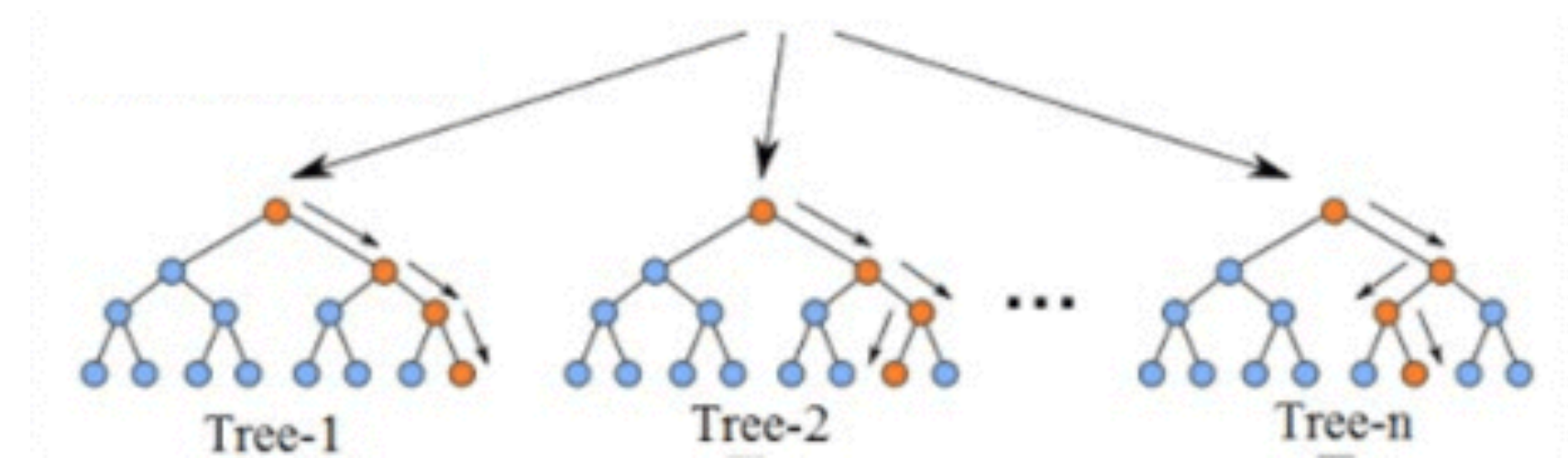
Use 7 predictor variables:



To train models to predict collected waste:

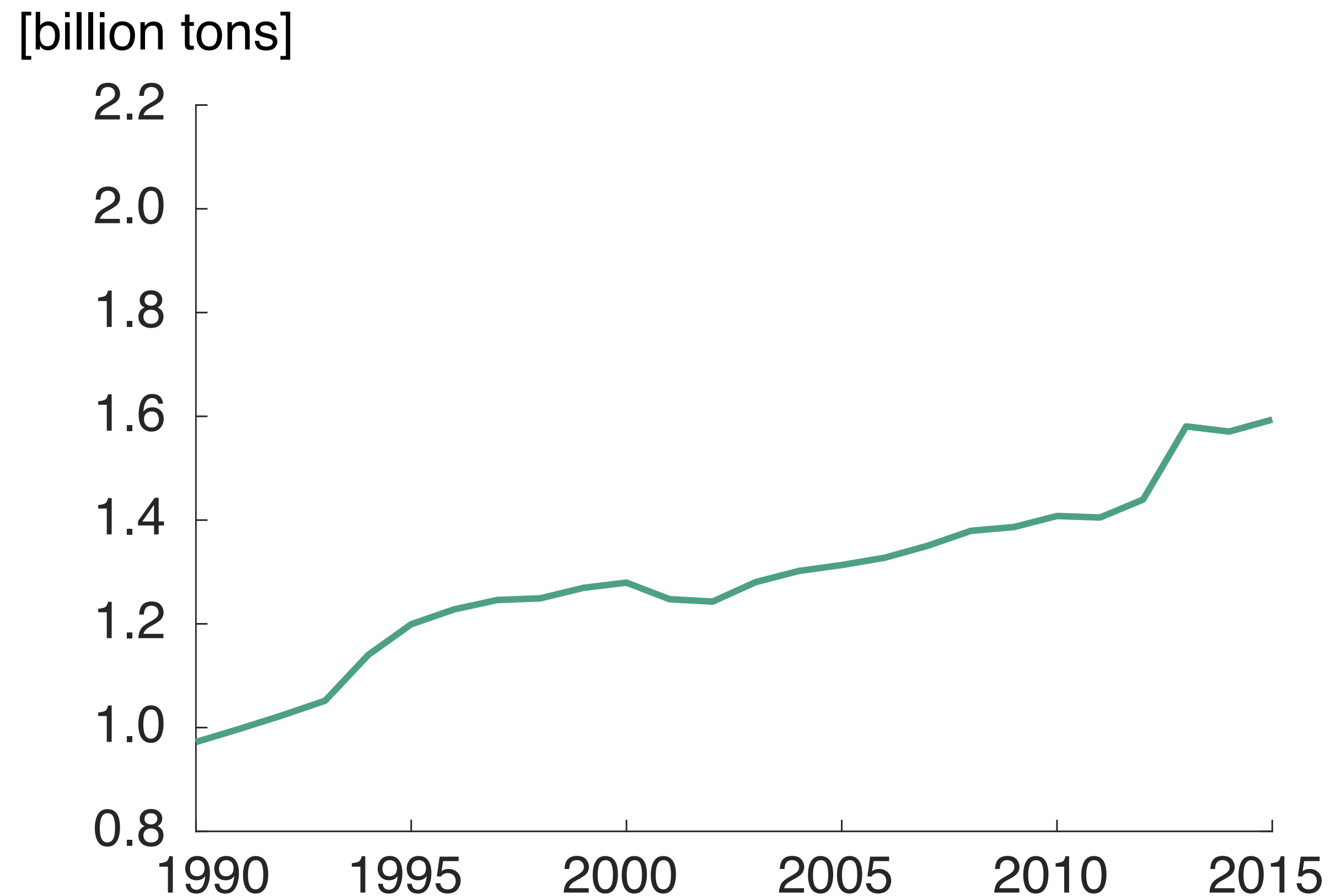


Linear mixed model



Random Forest

Estimated global collected waste

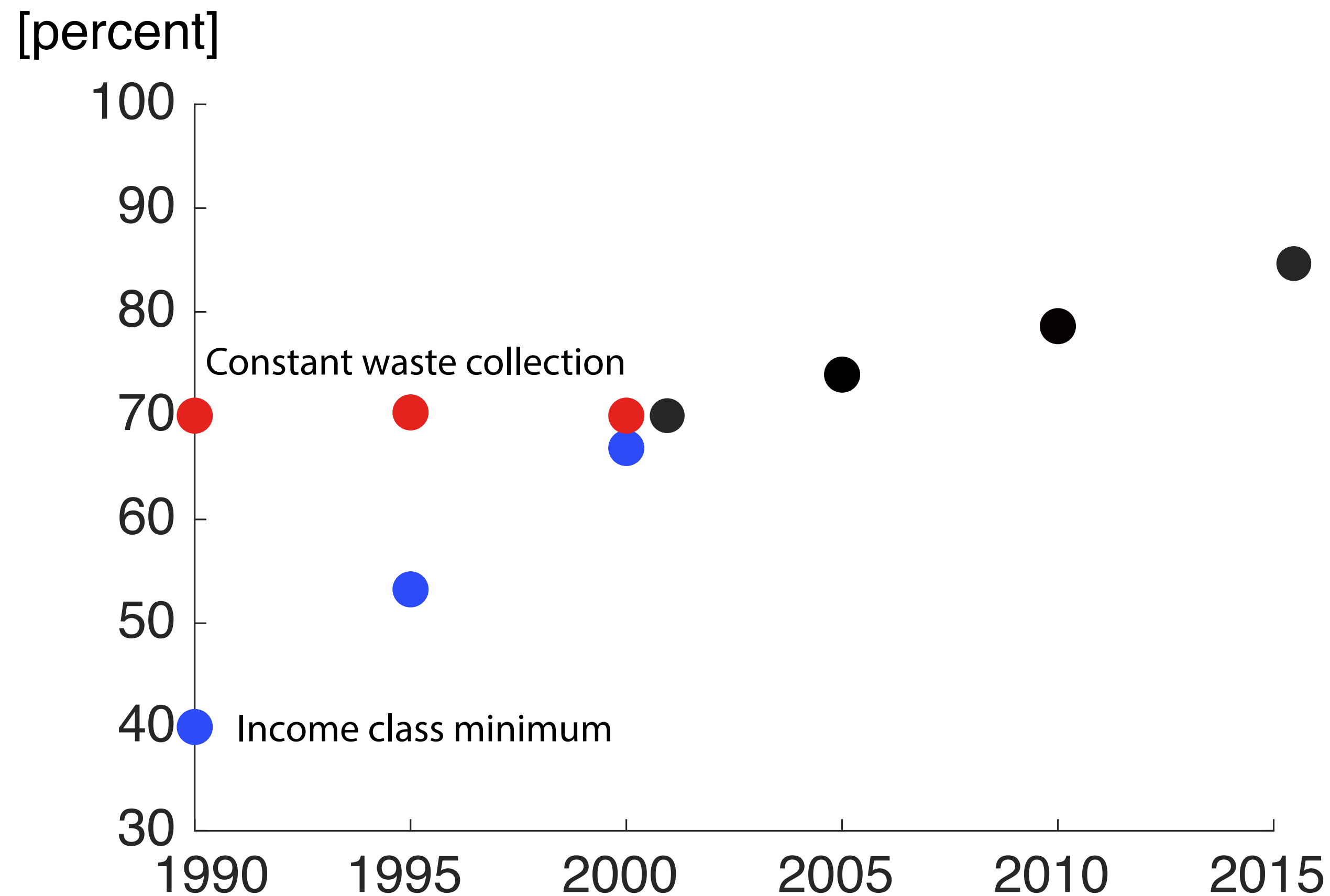


Evaluation:

Median error on all known 1405 values is $\pm 3.8\%$

90% of prediction errors are $<16\%$
Some outliers with large errors!

To estimate the uncollected fraction:



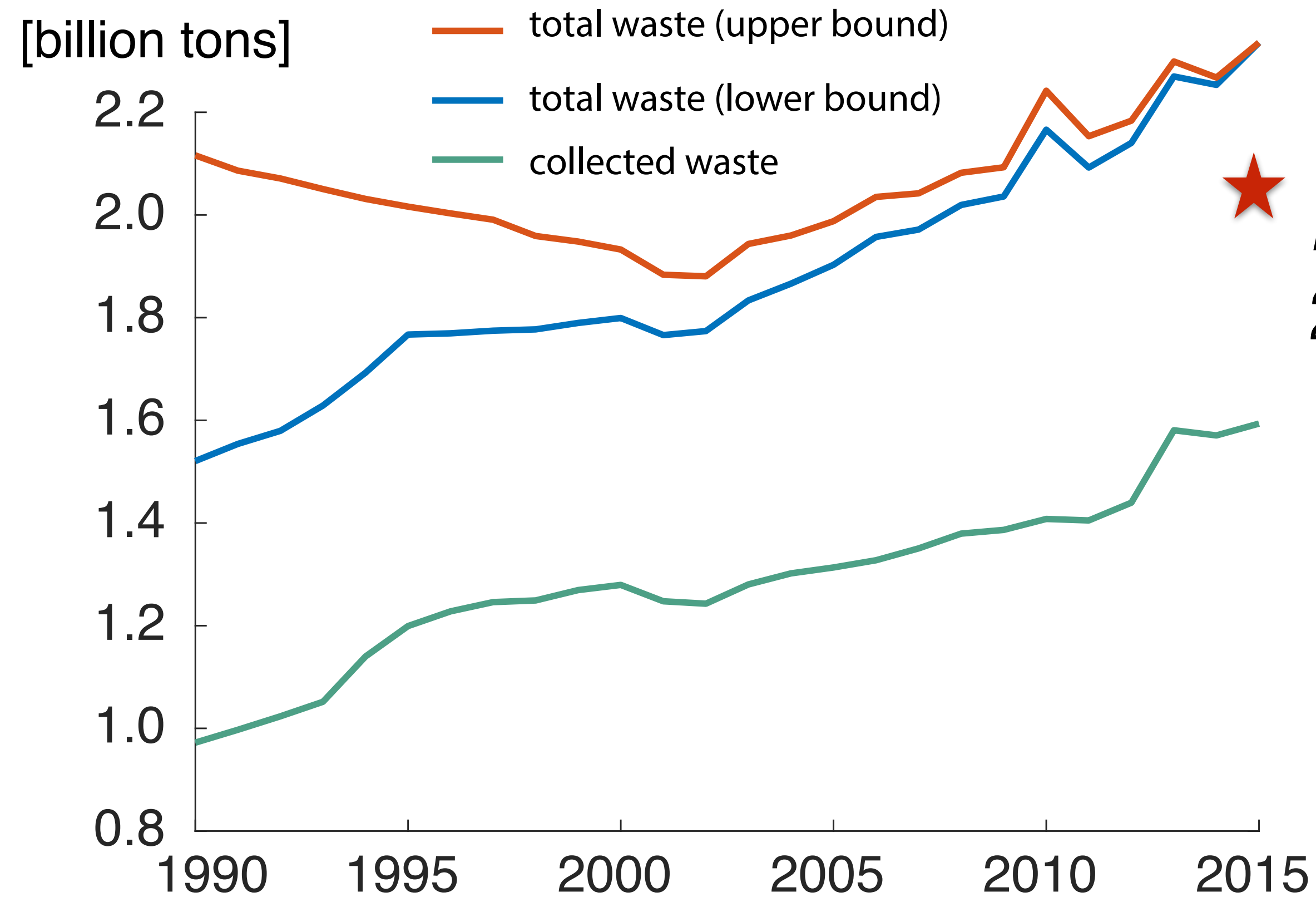
2015: Information on % waste collection mostly available

upper bound: assume constant waste collection

lower bound: set income class minimum as 1990 waste collection

connect all dots linearly

Predicted global total waste (collected + uncollected)

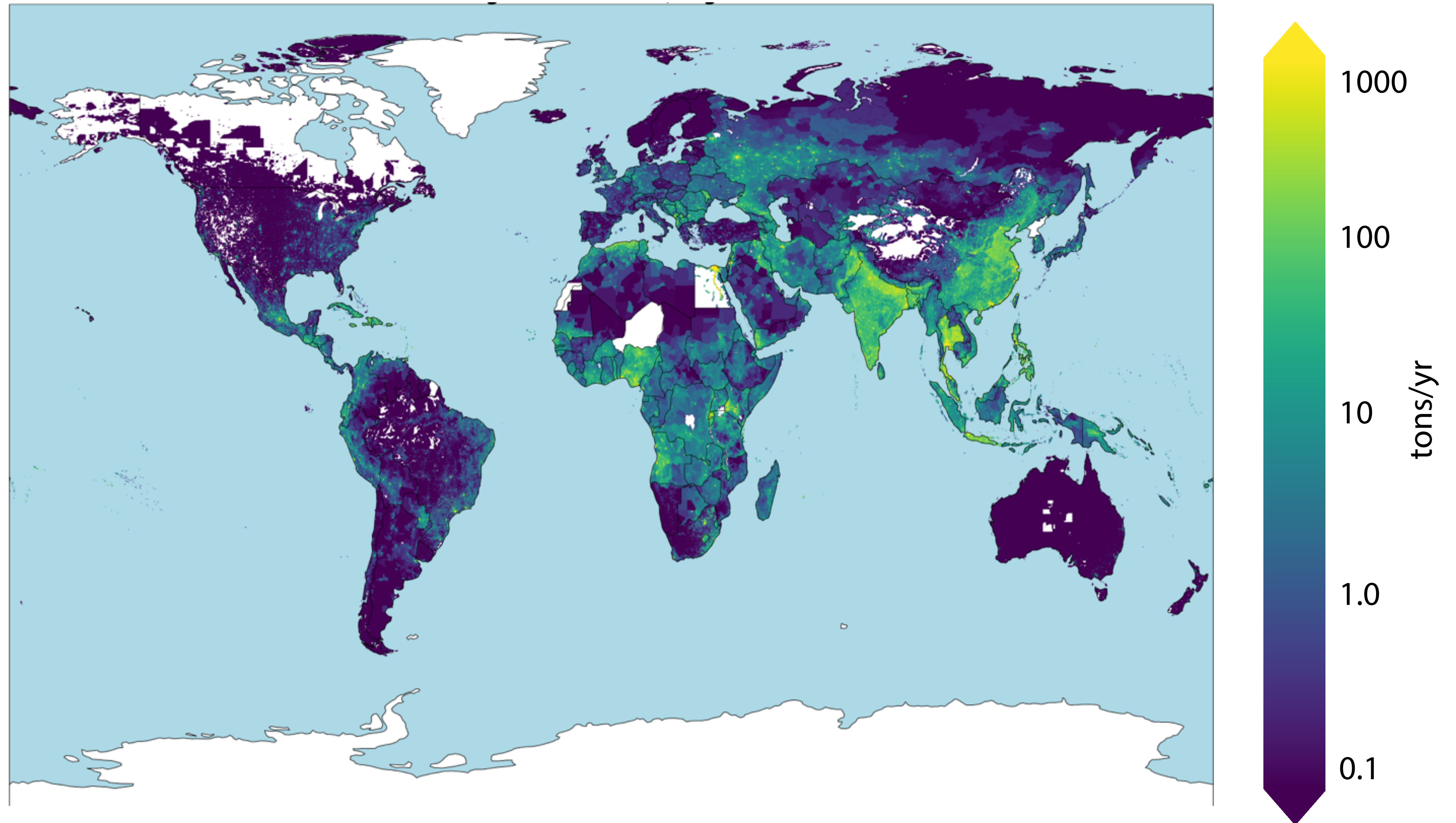


*World Bank Total waste estimate,
Kaza et al. (2018):
2.01 billion tons in 2015*

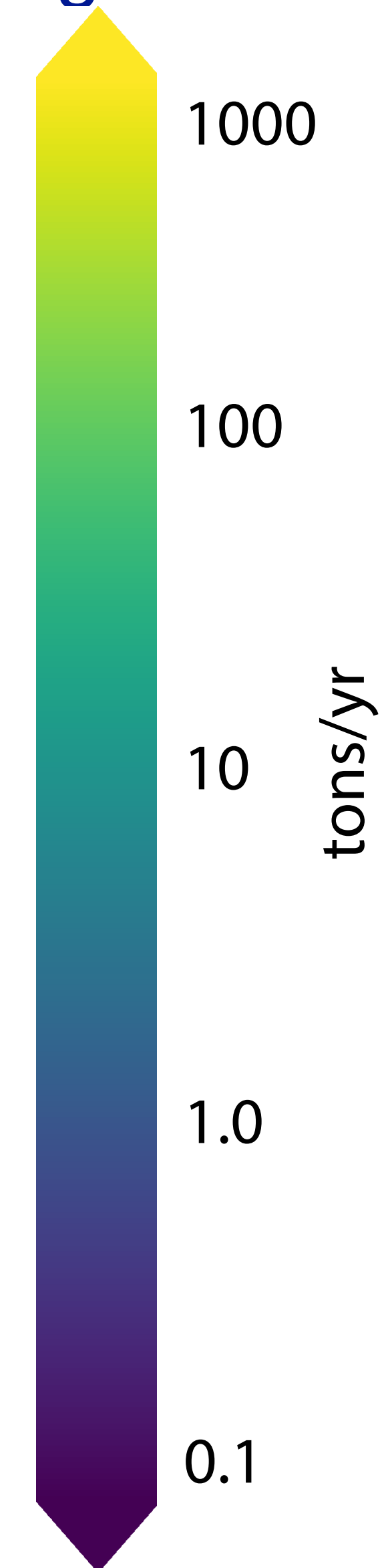
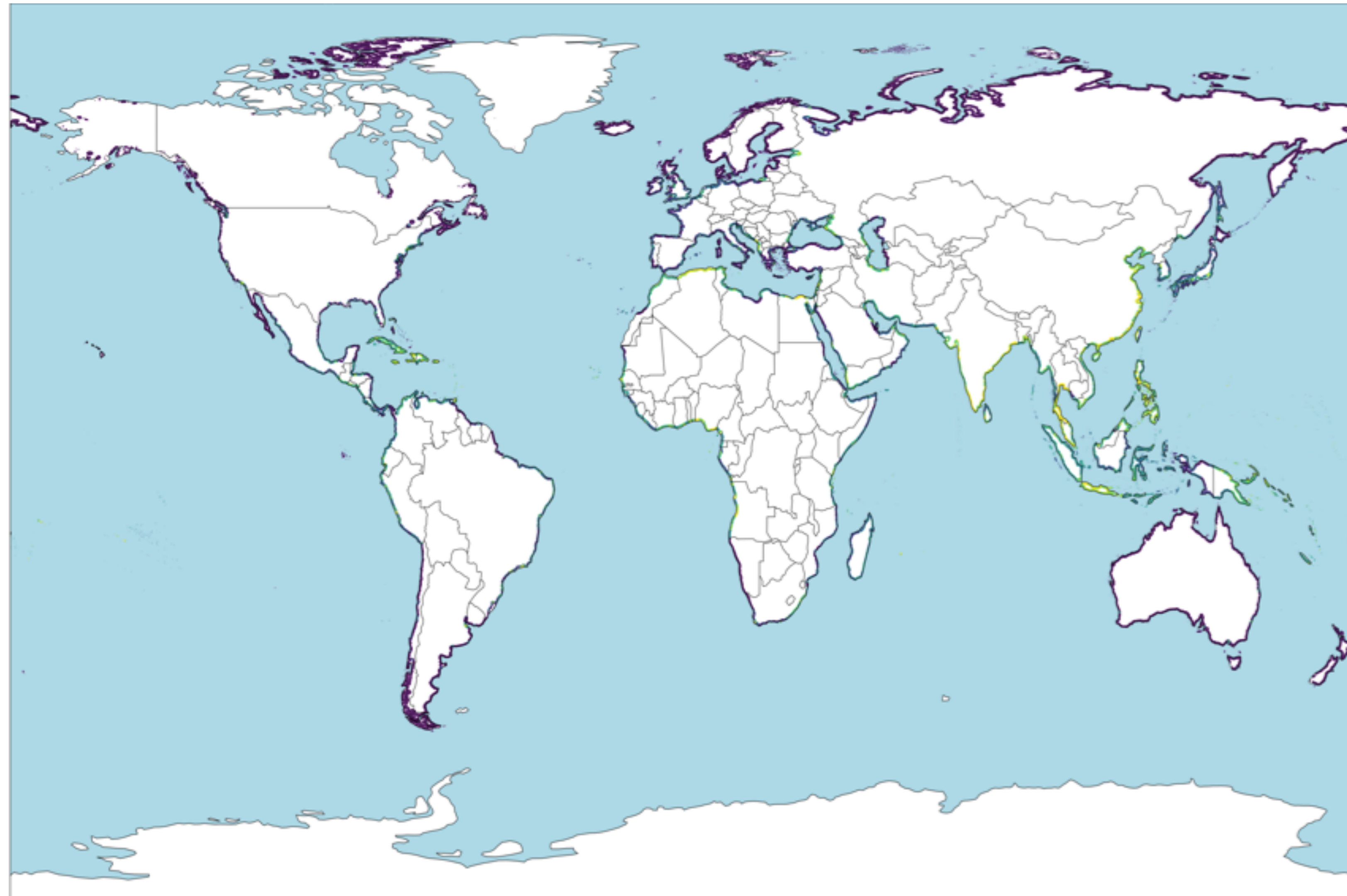
Mismanaged plastic waste (following Jambeck et al. 2015)

Upscale: Waste generation per person * population (0.1 deg resolution)

Urban waste generation = 2x rural waste generation
(e.g. Karak et al. 2012)



What part ends up in the ocean? (following Jambeck et al. 2015)

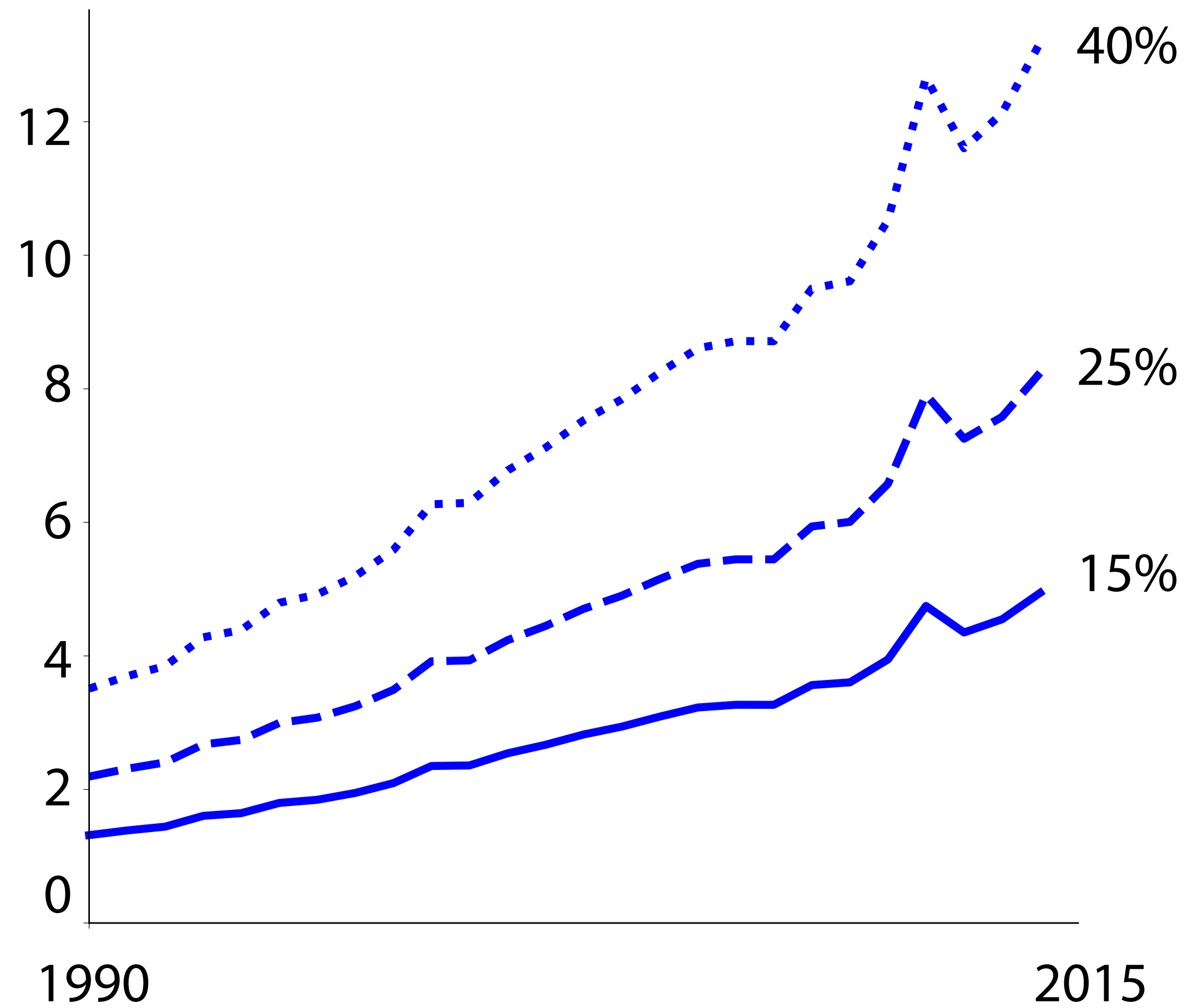


Consider
mismanaged
plastic within
50km of coast

Assume
15/25/40%
chance that it
enters the ocean

Estimated plastic input into the ocean 1990-2015

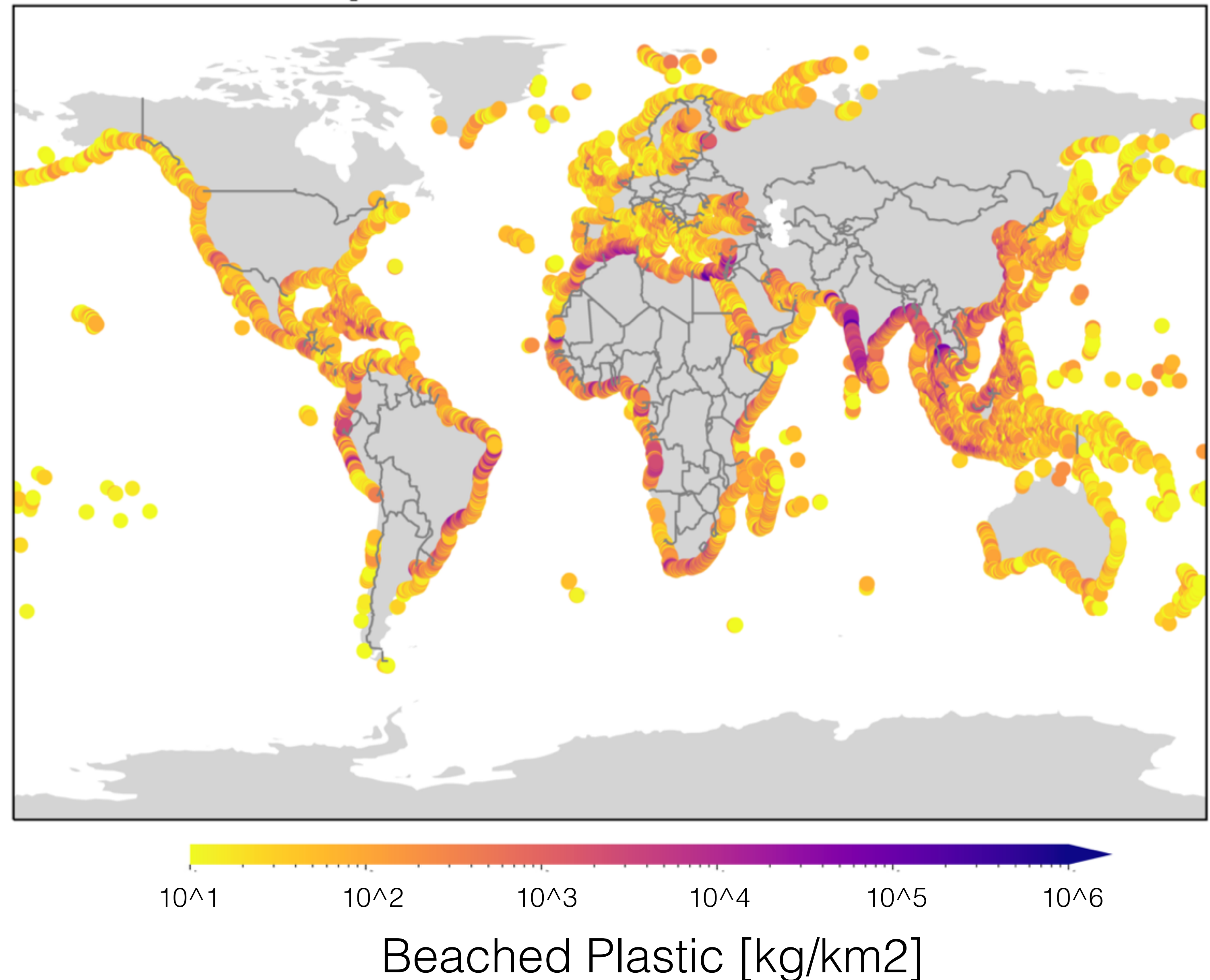
million tons



Accumulated input:
~26-91 mio tons

Beaching of plastic (Onink et al., in prep)

We are currently
running
several beaching
model experiments
Here is our current
best estimate for the
global pattern of
beached plastic



Summary

- **Estimates of global plastic waste generation (collected and total)**
 - Caveats:
 - uncertain waste data
 - ~median 3.8% model error (collected waste)
 - wide upper/lower bound (total waste)
 - presumably 10% error in plastic fraction estimate
- Following the *Jambeck et al.* approach, **26-91 million tons plastic entered the ocean between 1990-2015**
- First beaching model experiments indicate exponential distribution of beached plastic, highest values in South-east Asia, lowest values in high latitudes