



ACCESS THE FULL STUDY

# Trash to Treasure

Experts suggest that hundreds of new mines will need to be opened to provide the **ETM** necessary to meet 2050 renewable energy targets. But actually, ETM are all around us, in immense **above-ground sources** that are currently overlooked as waste. Our study assessed the ETM potential of all officially reported waste dumps, mine tailings, airplane boneyards, and ship-breaking yards to see how much we could grow the ETM supply just by **cleaning up these existing sites**. This could reduce the pressure to open new mines in sensitive ecosystems: a big win for people, the environment, and ETM supply security.



### What is ETM?

Energy transition minerals (ETMs) like copper, lithium, nickel, cobalt, and rare earth elements are crucial for electrification technologies such as wind turbines, solar panels, and batteries.



### What is an above-ground source?

It's the opposite of a mine, which extracts geological, or 'below-ground' mineral and metal. It is an innovative way to reimagine our growing waste problem.



### Why clean up these sites?

Often located in or near already vulnerable communities, many of these sites pollute soil, air, and water, create public health problems, and displace traditional land-based livelihoods.

## Airplane Boneyards

Large-scale storage areas for decommissioned aircraft

We analyzed 2,858 airplanes sitting in boneyards, but the 88,193 aircraft currently in use should be counted as future ETM sources

The 2,858 airplanes would provide:

- 9 kt Manganese
- 11 kt Nickel
- 4 kt Cobalt
- 0.2 kt Rare Earth Elements



## Mine Tailings

The leftovers from a mining operation, consisting of pulverized rock, water, and processing chemicals

We analyzed 1,947 sites, but we estimate that at least 44,000 are undisclosed

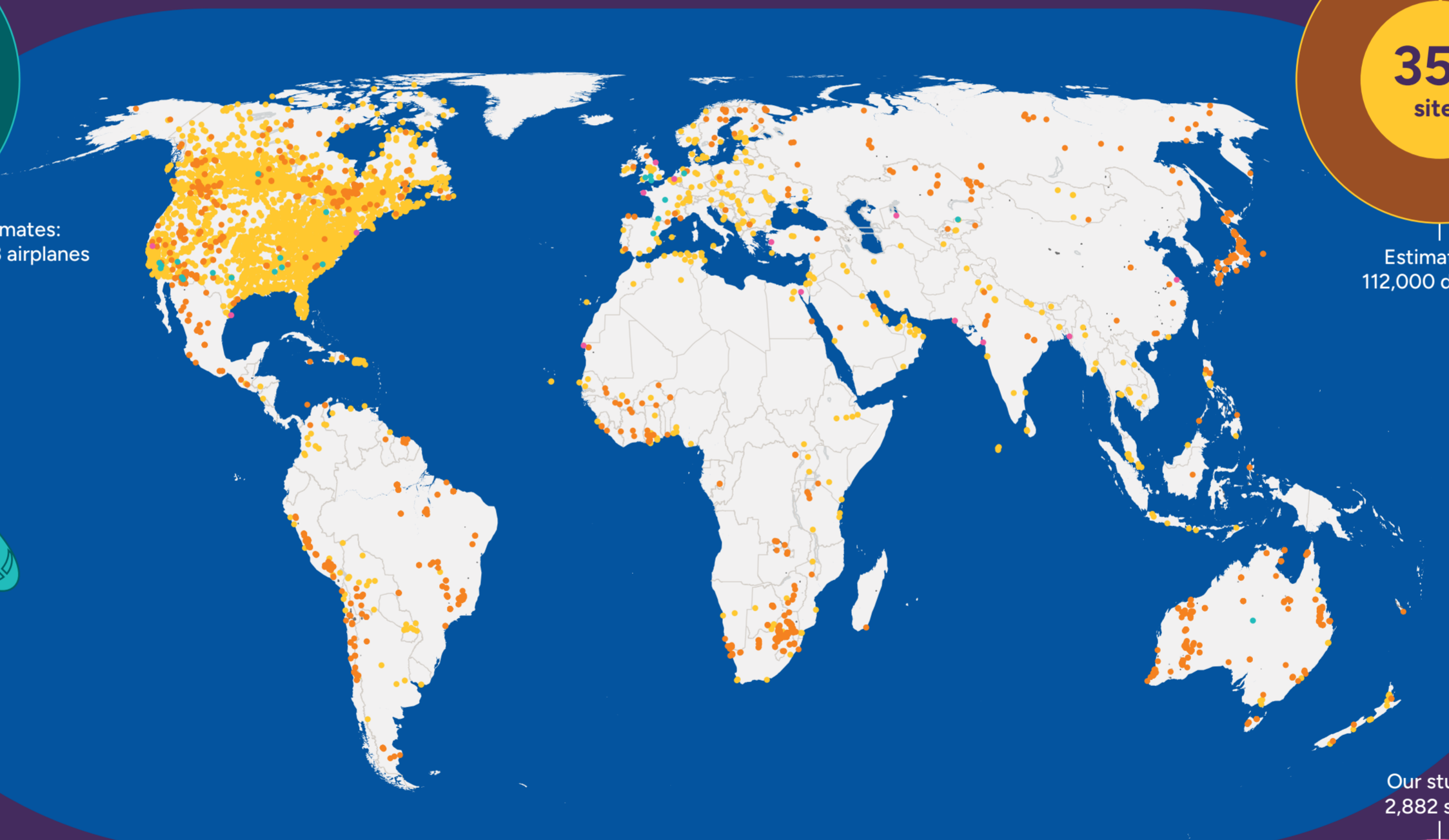
In the US alone, a recent study\* found that improving recovery of existing mine tailings could meet nearly all domestic demand for critical minerals

\* Holley et al. "By-product recovery from US metal mines could reduce import reliance for critical minerals." Science 389.6767 (2025): 1325-1331.



### Officially Reported Locations

- Waste dumps
- Mine Tailings
- Airplane Boneyards
- Ship-Breaking Yards



Our study: 352 sites



Estimates: 112,000 dumps



## Waste Dumps

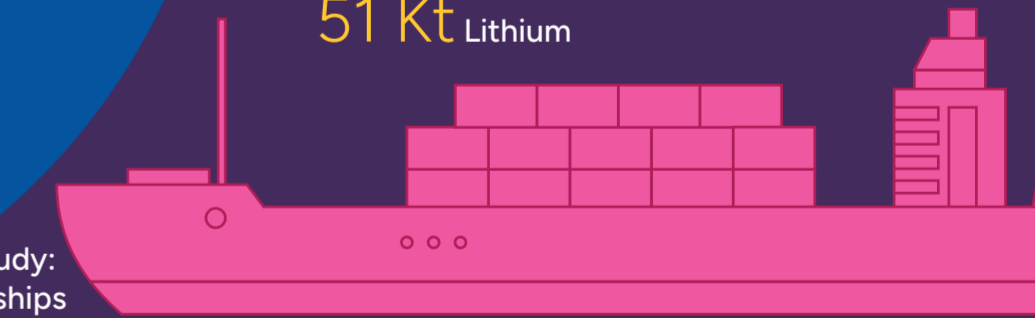
Solid waste disposal facilities

Most ETM recovery studies focus on incineration residues rather than unsorted municipal waste, and global waste systems rarely separate out metal-rich materials.

We analyzed 352 waste dump sites, but we estimate the 112,000 are undisclosed

The 352 dump sites would provide:

- 2,000 Kt Copper
- 562 Kt Chromium
- 51 Kt Lithium



Our study: 2,882 ships



Estimates: 112,495 ships

## Ship-Breaking Yards

Coastal facilities where large ships are dismantled and scrapped

We analyzed 2,882 ships found in 15 ship-breaking yards, but the 112,495 currently active ships represent future ETM sources

The 2,882 ships would provide:

- 130 kt Zinc
- 51 kt Silicon
- 32 kt Aluminium

### About the Data

To avoid overestimating, we limited our analysis only to the best available data about places that have been officially reported and mapped.

But the best available data only covers an estimated 1-4% of the global total of above-ground sources, which means **most of the world's above ground sources are uncounted!**

This is why, for example, it looks like most waste dumps in the world are located in North America, even though waste dumps are found all over the world.

**CLEANING UP ABOVE-GROUND SOURCES CAN GENERATE A NEW SOURCE OF ETM CLOSER TO CONSUMING MARKETS WHILE ALSO ADDRESSING LONG-STANDING WASTE PROBLEMS**



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# More ETM supply, less destruction

Growing the ETM supply by cleaning up existing waste sites is a win-win that exposes the inefficiency and unnecessary destruction of opening new mines. Lands stewarded by Indigenous and Land-Connected Peoples are crucial for climate mitigation, adaptation, and resilience. But most remaining untapped geological deposits are located in these precious ecosystems. That's why it's important to identify alternatives to mining below-ground ETM.

**What is ETM?**  
Energy transition minerals (ETMs) like copper, lithium, nickel, cobalt, and rare earth elements are crucial for electrification technologies such as wind turbines, solar panels, and batteries.

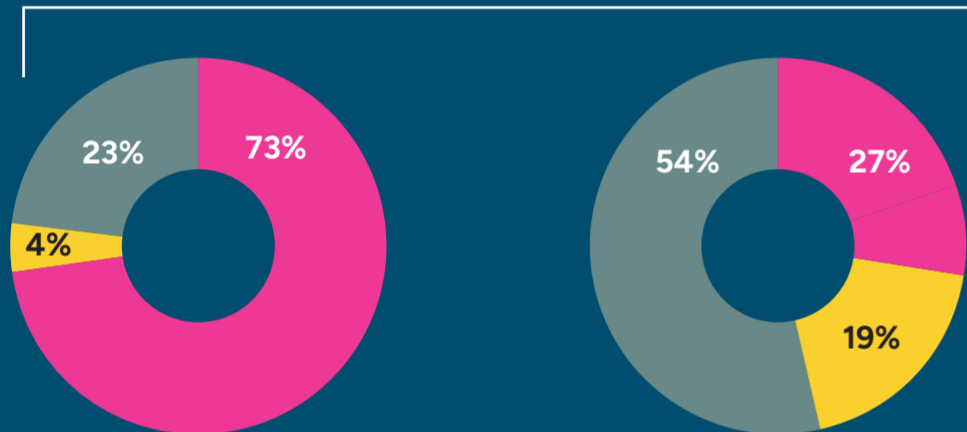
**Sites by location**

- Combined Indigenous, and Land-Connected Peoples', and Forested Lands Change
- Urban Area
- Other Land Types

## Why destroy this...

More than 50% of known geological (below-ground) reserves for many ETM are located in the lands of Indigenous and Land-Connected Peoples.\*

### Below ground



ETM deposits

Mines

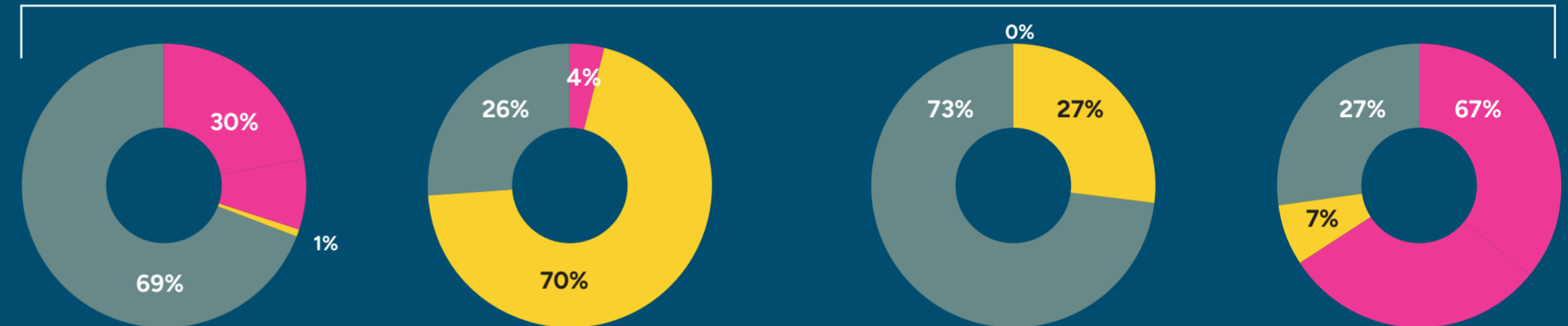
### IS MINING UNAVOIDABLE? NO, THERE IS A BETTER WAY.

It is possible to avoid exploiting new ETM deposits if we redirect geological exploration toward identifying above-ground sources.

## ...when we can repurpose this?

Around the world, the waste problem is growing while clean-up efforts are lagging. Many types of waste are rich in ETM and are dumped close to urban areas. This offers an untapped source of ETM in many of our own backyards.

### Above ground



Tailing dam

Airplane boneyard

Ship breaking sites

Waste dumps

### ETM RESERVES AND RESOURCES IN INDIGENOUS AND PEASANTS' LANDS

Bauxite	94%
Graphite	90%
Lithium	87%
Molybdenum	86%
Platinum	84%
Manganese	81%
Lead	80%
Vanadium	80%
Copper	78%
Ironore	78%
Zinc	78%
Nickel	76%
Tin	74%
Silver	74%
Cobalt	72%
Tungsten	70%
Rare earth elements	68%

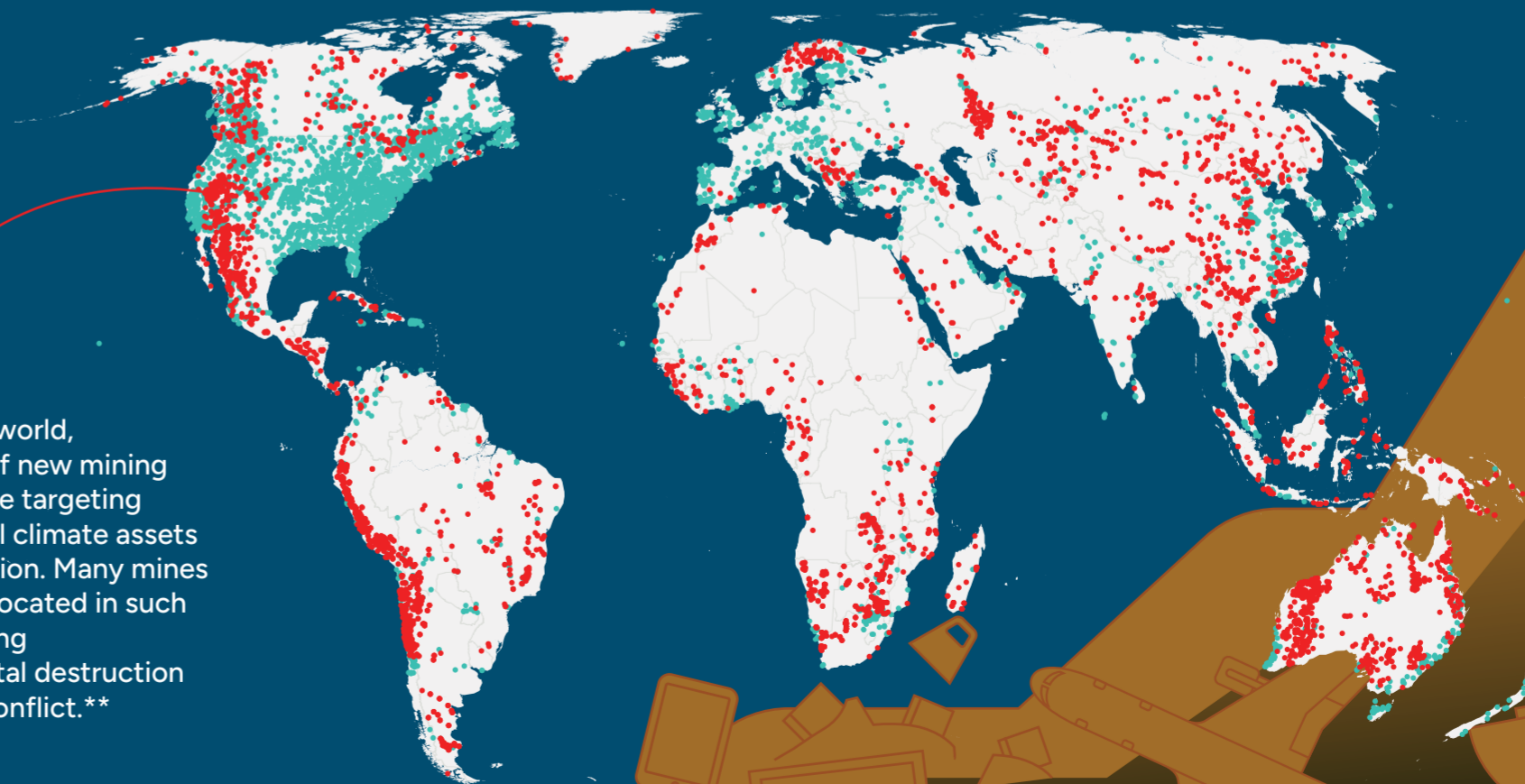
### SAFER ETM SOURCING

What happens to ETM supplies if Indigenous Lands are left undisturbed? Where will ETM come from? To figure this out, we overlaid ETM sources with officially designated Indigenous lands. While all operations must proceed with caution, we labeled ETM sources located outside of Indigenous Lands as "yes-go" zones. ETM sources found in Indigenous Lands are labeled "no-go" zones\*\*\*

● No-go zones ● Yes-go zones



Around the world, thousands of new mining proposals are targeting these crucial climate assets for exploitation. Many mines are already located in such places, driving environmental destruction and social conflict.\*\*



\*Owen, J.R., Kemp, D., Lechner, A.M. et al. Energy transition minerals and their intersection with land-connected peoples. Nat Sustain 6, 203–211 (2023). <https://doi.org/10.1038/s41893-022-00994-6>

\*\*Jamison, A. S., Tadmor, D., & Henisz, W. J. (2025). Indigenous peoples' reactions to foreign direct investment: a social movement perspective. Journal of International Business Studies, 1-19.

\*\*\*Inspired by: Cowan, O.S., Henry, D.A. and Little, I.T., 2025. The Threatened Species No-Go Mapping Tool: An online open-access land-use decision support tool that identifies areas of importance for highly sensitive species of conservation concern. Ecological Solutions and Evidence, 6(3), p.e70075.



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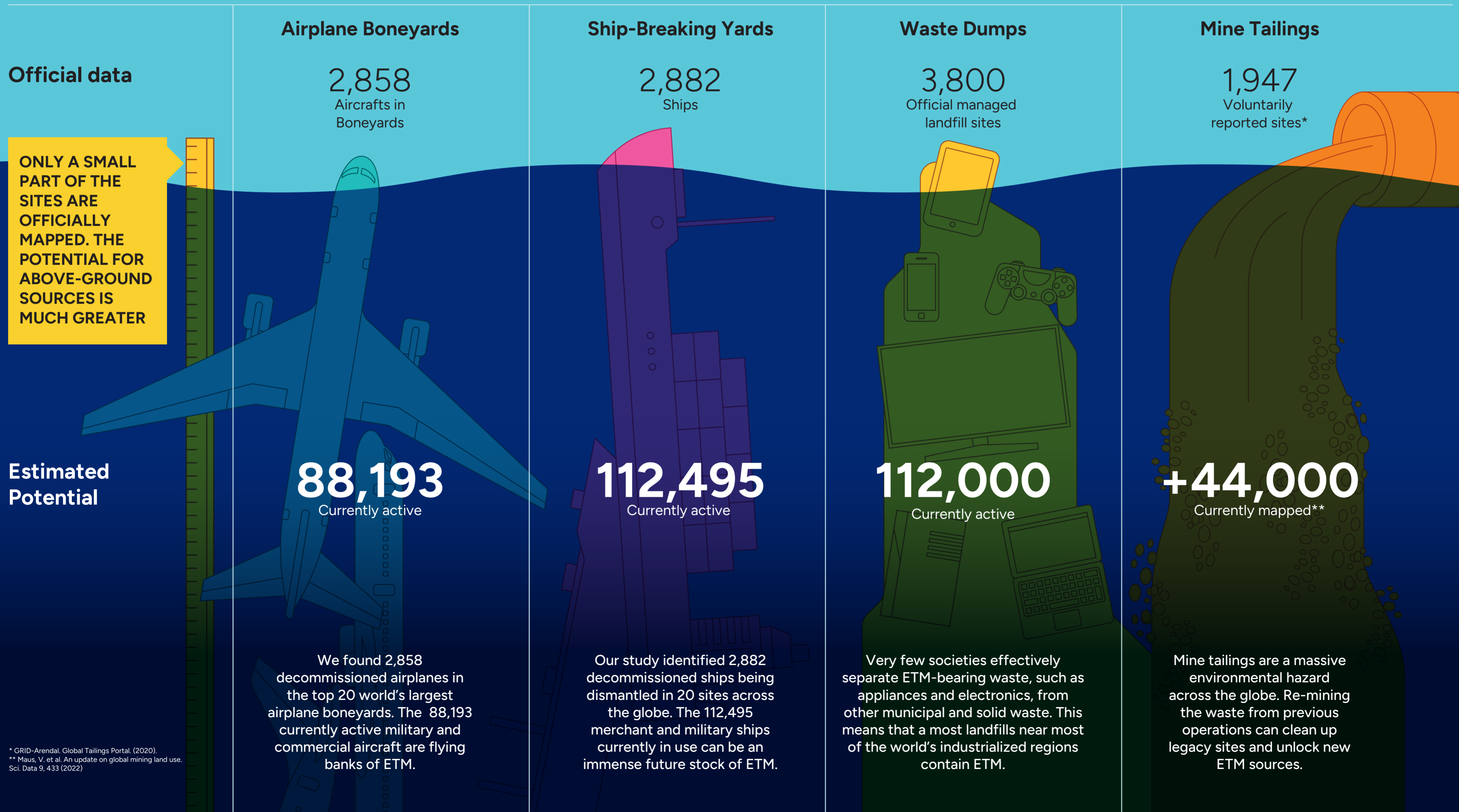
# Discover the alternatives

By analyzing only officially reported and mapped locations, our study uncovered the tip of the iceberg. We estimate that 95-99% of current and potential **ETM** above-ground sources are waiting to be documented and understood. **But every year, billions of dollars are spent on geological exploration.** A fraction of that investment in mapping above-ground sources could lead to immense new discoveries.



### What is ETM?

Energy transition minerals (ETMs) like copper, lithium, nickel, cobalt, and rare earth elements are crucial for electrification technologies such as wind turbines, solar panels, and batteries.



## Official data

ONLY A SMALL PART OF THE SITES ARE OFFICIALLY MAPPED. THE POTENTIAL FOR ABOVE-GROUND SOURCES IS MUCH GREATER

## Estimated Potential

### Airplane Boneyards

2,858  
Aircrafts in Boneyards

88,193  
Currently active

We found 2,858 decommissioned airplanes in the top 20 world's largest airplane boneyards. The 88,193 currently active military and commercial aircraft are flying banks of ETM.

### Ship-Breaking Yards

2,882  
Ships

112,495  
Currently active

Our study identified 2,882 decommissioned ships being dismantled in 20 sites across the globe. The 112,495 merchant and military ships currently in use can be an immense future stock of ETM.

### Waste Dumps

3,800  
Official managed landfill sites

112,000  
Currently active

Very few societies effectively separate ETM-bearing waste, such as appliances and electronics, from other municipal and solid waste. This means that a most landfills near most of the world's industrialized regions contain ETM.

### Mine Tailings

1,947  
Voluntarily reported sites\*

+44,000  
Currently mapped\*\*

Mine tailings are a massive environmental hazard across the globe. Re-mining the waste from previous operations can clean up legacy sites and unlock new ETM sources.

\* GRID-Arendal, Global Tailings Portal. (2020).  
\*\* Maus, V. et al. An update on global mining land use. Sci. Data 9, 433 (2022)