Testimony of Dustin Mulvaney, Professor,
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House Committee on Science, Space, and Technology
The Role of Federal Research in Establishing a Robust U.S. Supply Chain of Critical Minerals and Materials
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Introduction

Good morning, Chairman Lucas, and Ranking Member Lofgren, thank you for the opportunity to testify before this committee.

My name is Dustin Mulvaney and I am a Professor in the Environmental Studies Department at San José State University, and a Fellow at the Payne Institute for Public Policy at the Colorado School of Mines. This testimony reflects my views and expertise on the subjects of critical minerals and materials, supply chains, and circular economy.

Whether it is “critical minerals” or “strategic and critical materials,” experts widely agree that there are serious risks posed by weak and fragile critical mineral and material supply chains to national security, domestic industries, and critical infrastructure sectors. The United States in 1973 was the top producer of non-fuel minerals, and that position 50 years later has been ceded largely overseas, making the United States import dependent on many critical minerals and materials. The very existence of national strategic stockpiles reflects these dynamics and the consequences of supply chain disruptions to national defense or disaster response.

Lawmakers in the United States have recognized this in a series of public policies—including the 2020 Energy Act and 2021 Infrastructure Investment and Job Act (IIJA), as well as other executive actions intended to strengthen the resilience of supply chains, which will have the added benefits of geographic diversification, reduced environmental impact, and spurring innovation.

I would like to emphasize continued and further support in several areas of research and regulation that would make critical mineral and material supply chains more resilient and improve social and environmental outcomes.

1. Promote more circular economy approaches to the critical minerals and materials management

To promote more circular approaches to critical mineral and materials use, we need both carrots and sticks. We need investments in research and development in everything from basic science to pilot production facilities. But at the same time, there are enormous gaps in the critical mineral and materials loop before we realize a circular economy that warrant attention. Recovering and reusing critical minerals and materials from waste flows will help close these gaps.

Federal investments in research and development for critical minerals and materials will be greatly enhanced with comprehensive and enforceable standards. This includes policies that require (1) extended producer responsibility—holding producers responsible for the safe disposal of products they make, (2) green design—requiring products be made of safer materials that are easier to recycle, and (3) setting high benchmarks for recycled content in new materials, helping foster emerging domestic markets in recycled and recovered materials.

These efforts in tandem—investments in research and development, and setting comprehensive rules and standards—will enhance critical mineral and material supplies and strengthen domestic supply chains. This will further reduce the need for primary extraction and mining activities and reduce the burden on local landfills, materials recovery facilities, and the communities they are located.

The new battery regulation in the European Union released in August 2023 is a good starting point for a circular economy approach to managing lithium-ion batteries that could be replicated here and for other products that contain critical minerals and materials. The rules require that battery producers meet specified social and environmental standards across the entire life cycle of the product including a product end-of-life management plan.

2. **Require extended producer responsibility, take back and collection systems, and avoid toxic materials in products**

A similar take back program for lithium batteries as Europe has would close an important gap as only 10% to 15% of lithium ion batteries are currently collected in the United States. Recycling efforts could recover cobalt, nickel, manganese, lithium, graphite, aluminum and copper, and would bring environmental benefits as well. Recycling can significantly augment critical minerals and materials supplies. Some estimates suggest that recycled supplies could satisfy up to 25% for lithium, 35% for cobalt and nickel and 55% for copper, based on projected demand and technology adoption scenarios. According to the Copper Alliance, less than 40% of global copper is currently recycled. According to research from Fraunhofer Institute for Systems and Innovation, 2/3rds of end-of-life copper are sent to landfills annually. Recycling some critical minerals and materials can avoid up to 90% of the energy used to produce them from natural resources.

The reason these materials go uncollected is the lack of rules and regulations that require their recovery and collection. According to a 2022 GAO report, "DOE officials stated that most critical minerals, such as rare earth elements (REE), are not collected for recycling on a large scale, in part because of variations in recycling programs" (p 16, GAO 2022). Where recycling infrastructure is in place, "according to a US EPA report, U.S. recyclable collection infrastructure is outdated." (p. 17, GAO, 2022).

Germanium and gallium are two critical minerals and materials that representative of challenges posed by a lack of extended producer responsibility. They were in the news last August (2023) as critical minerals that would be restricted from export by China. Yet we do very little recycling of LEDs, scrap materials, and everyday devices and appliances containing germanium- and gallium-based semiconductors including microwaves, blue ray players, and other electronic products that are often landfilled today. No gallium is recycled in the United States and China produces 98% of that global supply. Only small amounts of germanium are recovered and exported for recycling. Germanium and gallium often are alloyed in a way that complicates recovery. Use of critical minerals in low concentrations in alloys like this is another area where research into substitutes could allow more minerals to be available for green infrastructures.

The U.S. should develop regulations and invest in more efforts like the recently developed Defense Logistics Agency program for recycling optical-grade germanium used in military weapons systems that will result in supplying up to 10% of the materials needed for next generation equipment in a few years.

Finally, avoiding toxic materials in electronic products and devices are also critical to a just and equitable circular economy. Effective public policy—much like Europe's Restriction on Hazardous Substances—that reduce toxic exposures can help ensure that workers and communities where recycling and recovery facilities are located will not be harmed by the operations of these infrastructures.

Utilizing the purchasing power of the federal government could be used to set some of these standards through procurement. The US EPA encourages the use of the EPEAT standard for federal purchases and this standard could be utilized to encourage emerging markets in recovered critical minerals and materials by, for example, requiring certain percentages of recycled content in federal purchases, avoid materials of concern in product, or that producers have a take back and collection program. This would send market signals to would be recyclers. However, private certifications like these are sometime the only option absent regulation; comprehensive extended producer responsibility is still the most effective path to recovering end-of-life critical minerals and materials.

3. **Recover more critical minerals and materials from waste at industrial sites and increase resource efficiency**

Waste is an important resource for critical metals. With over 400,000 to 500,000 abandoned mines in the United States, according the several estimates, policies and practices that encourage waste and tailings use at mine sites is another strategy to augment critical mineral supplies. There are also opportunities to recover these materials from coal ash, red mud, slag piles, mine tailings, and other wastes. Critical minerals and materials recovery from mine waste could be pursued alongside environmental remediation, where work to process materials may be underway anyways for cleanup.

To help encourage more critical minerals and materials from waste flows, lawmakers should augment IIJA investments in recycling processes. Product materials are complex and require experimentation with different technique from chemical processing to materials science. More innovative methods and techniques for critical materials recycling should continue to get support to clean up legacy mine sites and procure more critical minerals and materials from waste.

Materials recovery in mining and downstream processing in the market is optimized for profitability not maximizing materials or biproducts. More incentives to develop biproducts, recover materials at smelters, or increase recovery rates could help drive up recycling of materials. Smelters in the United States are not designed to recover many critical minerals; for example, there are no domestic smelters that can recover cobalt.

We can increase the resource efficiency of many of the materials we use today. There are excellent examples of resource efficiency avoiding significant amounts of critical minerals and materials. A photovoltaic module today, thanks to increased resource efficiencies, uses about five times less silver than a photovoltaic module yesterday. Similar, semiconductor wafers in the same technology are two to three times thinner than just a decade ago, avoiding polysilicon. This has translated to lower energy inputs and silicon feedstocks needed for the solar industry. We could recover even more with better take-back and collection programs.

There are other ways to increase resource efficiency across society as well. In a recent report from the Climate and Community Project they found up to 90% of lithium demand can be reduced by encouraging public transportation and more lightweight electric vehicles and other modes of transportation.

4. **Avoid dissipative uses of critical minerals and materials and increase input substitution.**

Some critical minerals and materials are used dissipatively, in lower concentrations than found in ores. Steel for example uses very low quantities of tellurium and aluminum and recovering such low concentrations requires correspondingly more energy. Innovations in materials science to replace materials used dissipatively which if substituted can be found can augment critical minerals supplies. Some screenings of critical minerals have found that most have dissipative use rates over 50%, which is consistently much higher than other metals.

Research that develops substitutes and alternatives to critical minerals and materials as sustainable ways to secure domestic supplies. This would help mitigate extensive impacts from extractive industries, which can be poorly regulated and environmentally-damaging. The critical mineral of concern a few years ago for lithium-ion batteries was cobalt. In a few short years, projections for use of cobalt—75% of which according to Benchmark Minerals currently goes to making lithium-ion batteries—has fallen dramatically with lowering of cobalt content and advances non-cobalt batteries. Companies concerned about bottlenecks and reputational risks have begun to eschew cobalt supply chains. We are already seeing companies move away from nickel and manganese as well in next generation in lithium iron phosphate batteries.

These shifts in technology are sometimes beyond the horizon. We do not necessarily know the battery chemistries and composition of tomorrow's lithium-ion batteries, how do we know which materials to prioritize for development today? The next generation batteries may have no lithium at all. We are also seeing the development of non-lithium batteries. One of the largest battery makers in the world BYD announced in August 2023 a partnership to build sodium-ion batteries and has plans to put in a popular and inexpensive electric vehicle. It is not clear how widespread this technology will eventually be, but it is a perfect of example of how materials demand can change in a short time. Not far off in the future, we are likely to see batteries that altogether avoid graphite, currently used as the anode in 95% of lithium-ion batteries today, as well.

5. Conclusions

The social and economic benefits of developing a circular economy for critical minerals and materials supplies are manyfold. Other implications of expanded recycling and collection systems for materials include job creation, infrastructure investments, and workforce development. Developing a value chain for various critical metals here in the United States can help buffer supplies that might be vulnerable to disruption. Developing leadership in this space could result in valuable industry as the value of battery recycling alone is poised to be over $95 billion per year by 2040 (McKinsey 2023).

I appreciate this opportunity to speak with you and look forward to any questions you might have. I will add supporting documentation for the points I've raised to the record. Thank you for your time and attention.

Dustin Mulvaney is a Professor in the Environmental Studies Department at San José State University (SJSU) and a Fellow with the Payne Institute for Public Policy at the Colorado School of Mines. His areas of expertise and research are on land use change, life cycle analysis, recycling & waste, and the environmental justice impacts of energy technologies, supply chains, and infrastructures. He has published research on numerous energy technologies with extensive emphasis on the life cycle impacts of solar photovoltaics and lithium-ion batteries, and has a Ph.D. in Environmental Studies from the University of California, Santa Cruz, a Master's of Science degree in Environmental Policy Studies, and a Bachelor's of Science degree in Chemical Engineering, from the New Jersey Institute of Technology. Professor Mulvaney's professional private sector experience includes work in chemical manufacturing, environmental remediation, and environmental consulting. He has been an expert witness at the California Public Utilities Commission for 13 years, and has participated in the development of waste, land use, and energy policy with California legislators, and state and county agencies over the past decade. Professor Mulvaney serves on the Technical Advisory Committee to the Recycling and Waste Reduction Commission of Santa Clara County, the Technical Committee for an Ultra-Low Carbon Solar Standard for photovoltaics recently developed by the Green Electronics Council, and is part of the Lithium Valley Equity Technical Advisory Group advising Comite Civico del Valle on issues related to the development of geothermal and lithium near the Salton Sea in Imperial County, California.