**Testimony of Dustin Mulvaney, Professor, Environmental Studies, San José State University, before the House Natural Resources Committee, Subcommittee on Energy and Minerals, Wednesday, September 13, 2023**

The Honorable Pete Stauber
Chair, Subcommittee on Energy and Mineral Resources
House Natural Resources Committee
1324 Longworth House Office Building
Washington, D.C. 20515

## Introduction

My name is Dustin Mulvaney and I am a Professor of Environmental Studies 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 topics herein, and I am not speaking on behalf of my affiliated organizations or anyone but myself.

My 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. I have published research on numerous energy technologies with extensive emphasis on the life cycle impacts of solar photovoltaics and lithium-ion batteries. I have 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, the latter two from the New Jersey Institute of Technology. My professional private sector experience includes work in chemical manufacturing, environmental remediation, and environmental consulting. I have been an expert witness at the California Public Utilities Commission for 13 years, and have participated in the development of waste, land use, and energy policy with California legislators, and state and county agencies over the past decade. I serve 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 am 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.

Thank you for the opportunity to testify before this committee. Special thanks to the committee staff, and thank you for your attention to these important matters.

The development and strengthening of supply chains to support metals, minerals, and materials that we will need for decarbonization, green infrastructures, transportation, healthcare, and defense is of serious national importance.

Supply chain disruptions from bottlenecks, geographic concentration, and trade restrictions in recent years have shown vulnerabilities to the domestic economy and decarbonization efforts.

The dependence on critical minerals of many key technologies to the U.S. economy make securing adequate supplies crucial to the success of other important public policies including the 2021 Inflation Reduction Act and the Energy Act of 2020, and well as efforts by states and local government. The development of a critical minerals list is an excellent starting point for a conversation about how to develop clean energy supply chains responsibly and to the highest possible labor and environmental standards. We need a framework that brings together both the need for new responsible critical minerals development, but also that emphasizes circular economy approaches that can augment critical mineral supplies significantly in the short term.

To date, much of the conversation and public policy effort has focused solely on mining. But recycling, alternative extraction techniques, resource efficiency, and harvesting materials from waste streams offer significant promise for enhancing the nation's supply of critical minerals, and lessening the risks of and exposures to supply chain disruptions. These latter activities are more recently gaining attention and policy support, including from this Congress, which is welcome news to those of us that have long been working on waste and recycling issues.

While we cannot recycle or mine our way out of these challenges, we should be collecting as much of these critical minerals in the waste stream as feasible. It seems profoundly wasteful that we would allow critical materials be landfilled at the same time we talk about the dire national security consequences of a lack of supply and promote greenfield mine development elsewhere.

In the testimony that follows, I have several suggestions for areas that in my experience and understanding would result in helping make critical minerals supplies less vulnerable, while at the same time safeguarding environmental protection, cultural resources, respecting Native American self-determination and sovereignty, and creating quality high-road domestic jobs.

Building a circular economy on critical minerals should (1) Promote more circular economy approaches to the critical minerals challenge, (2) Develop robust take back and collection systems and recycling, (3) Recover more critical minerals from waste and increase resource efficiency, (4) Advance materials science, input substitution, and alternatives to hard rock mining, (5) Strengthen Tribal consultation, and (6) Reform the 1872 mining law, (7) Avoid unnecessary groundwater and ecological impacts, (8) Strengthen environmental review, (9) Provide community benefits.

Emphasizing these aspects will result in more secure critical minerals supplies as well more community acceptance of mining activities. Taken together these suggestions will help get more public support for responsible natural resource development, product stewardship policies, increased resource efficiency, and innovations in materials science and processing to augment supplies of critical minerals for the U.S. economy.

## 1. Promote more circular economy approaches to the critical minerals challenge

The National Academy of Sciences 2008 report recognized the need to analyze the risks posed by critical mineral supply chains for national security and domestic industries. The U.S. in 1973 was the top producer of non-fuel minerals, and that position 50 years later has been ceded largely overseas. The United States has recognized this in a series of public policies intended to strengthen the resilience of supply chains, which will have the added benefits of geographic diversification and reduced environmental impact.

The idea of criticality as the United States Geologic Survey uses it involves understanding supply risks across three domains (1) how likely a disruption is to occur, (2) how exposed a supply chain is to disruption, and (3) whether the disruption can be overcome. Copper for example is sourced from a wide variety of places. This geographic diversity means that disruption due to anything from geopolitics to natural disaster, does not rise to the level of risk of say gallium or germanium, where over 90% of production is concentrated in one regional geography.

**2. Develop robust take back and collection systems and recycling**

Despite concerns about the availability of copper and other metals, minerals, and materials, the federal government has no comprehensive electronics and electronical equipment waste take back and recovery law. This is missing opportunities to recover important inputs the United States economy will need from waste flows, and to avoid unnecessary mining. Recycling can significantly augment critical minerals supplies. Some estimates put these values at 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.

Waste flows from end-of-life electronic products often have significantly more critical minerals by percent than the ores they are obtained from in mining. Rare earth elements in end-of-life electronics are mostly lost through waste flows in the United States. Less than 5% of rare earth elements globally are recycled according to the trade press *Recycling International*. Recycling consumer electronic products and utilizing byproducts of other materials processing could yield double to ten times the rare earth elements that could be extracted through processing the raw materials. Three to four times more dysprosium can be obtained from recycling headphones than from rare earth element ores. An iPhone touch screen has more lanthanum to make those bright colors, than is typically found in rare earth element ores. Similarly, there is a higher percent of neodymium obtained from recycling wind turbine magnets, than are found in those rare earth element ores. In an era of declining ore grades, these waste flows should be seen as resources to boost critical mineral supplies.

Lithium-ion battery recycling rates are slowly ticking up, but still most collected at end-of-life are only recovered for copper, cobalt, nickel, graphite, and aluminum. We have not developed a lithium battery recycling ecosystem in the United States and as a result most lithium-ion batteries are sent to China, South Korea, and Europe for reprocessing into new feedstocks. This means not only are these places securing new supplies, they are developing the technologies to do so. Developing recycling infrastructure in the United States would allow battery recyclers to be suppliers of metal and minerals to materials refiners producing battery input precursors.

Developing recycling programs for electronic waste will hasten United States innovation in this space and allow it to catch up with the rest of the world on recycling technology.

Germanium and gallium were in the news last month (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. Small amounts of germanium are recovered and exported for recycling.

Tellurium is used in cadmium telluride photovoltaics and night vision goggles, and is 1000 times more rare than rare earths. Over 40% of the global tellurium supply goes to one photovoltaic supply chain. But tellurium also goes into steel dissipatively, meaning that the amount in the product is lower than that found in typical copper and gold ores where tellurium is obtained. Dissipative uses of critical metals typically means losing them to future products forever. More research into substitutes for materials used this way will free up existing supplies and encourage more recovery.

Indium is a critical mineral used to make indium tin oxide, essential to the functioning flat-panel displays, mobile phones, photovoltaics, aerospace and other telecommunications applications because of its conductivity and transparency. The production of indium is mostly in China, and countries like Japan have secured supplies of indium from indium tin oxide scrap at electronic waste recovery facilities.

Comprehensive electronic waste recycling rules can foster these emerging industries and technologies. Singapore created an extended producer responsibility law, and in 2021 opened its first battery recycling facility. Rules for end-of-life products can help ensure that emerging recyclers are recovering as much of the waste stream as possible. For these nascent recycling industries, getting waste volumes is critically important to economic viability and scale.

A recent *Wall Street Journal* article about Redwood Materials noted that the company is now valued at $5 billion. Redwood Materials claims a 90% reduction in greenhouse gas emissions using recycled cathode product as feedstock for new battery cathodes. These investments show that the battery recycling industry is ripe for growth and passing laws to encourage the take back and collection of batteries for recycling will only help these industries grow. American Battery Technology Company, Li-Cycle, and Ascend Elements are a few more companies in this space employing thousands of people and attracting private sector investment to recycling lithium ion batteries.

The European Union's Battery Directive and battery passport system requires supply chain due diligence, has strong environmental protections, from sourcing through end-of-life. A similar policy in the United States could go a long way to utilizing recycling to augment supplies of critical minerals. Battery manufacturers in the United States currently fund a non-profit to do some collection, but it still only about 5% of lithium-ion batteries that are collected; in Europe this number is closer to 40%.

PV Cycle has developed take back and recycling infrastructure for photovoltaics since 2007 and in Europe over 95% of photovoltaics are recycled, compared to less the 5% in the United States. This is because of the Waste Electronics and Electrical Equipment (WEEE) Directive promotes cradle-to-cradle materials handling and added photovoltaics to mandatory take back and recycling policy in 2014. The United States on the other hand, uses only a cradle-to-grave approach to materials management, only managing the most hazardous of electronics products. With the few photovoltaics collected in the United States today, very little silver, an element considered by not listed currently as a critical mineral, is recovered as the modules are mainly used as smelter flux and those smelters are not designed to recover silver. The solar industry uses over 10% of the global silver supply for metallization pastes.

The Green Electronics Council has developed an Electronic Product Environmental Assessment Tool (EPEAT) to leverage procurement in raising the environmental standards of photovoltaics, which supports companies with comprehensive take back and recycling programs. Federal government procurement could further help develop these programs as described by the U.S. Environmental Protection Agency: "EPA recommends the following private sector standards/ecolabels be used when purchasing photovoltaic modules and inverters or energy savings performance contracts or power purchase agreements."[1]

It seems imprudent to be letting critical minerals go to landfill or dissipative uses. We need to build the infrastructures for a circular economy in—not just critical minerals—but all metals and mineral flows that are practicable. One way to bring value to waste is to not let it be landfilled or disposed of for free. Extended producer responsibility and other product stewardship laws and programs can ensure that materials are diverted from landfill where it will never return to products.

### 3. Recover more critical minerals from waste 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 valorization" 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. Recovery of critical minerals from mine waste particularly looks promising in environmental remediation, where work to process materials may be underway anyways for cleanup.

Environmental remediation can be expensive, which is why it is important to modernize our mining laws, payments, and royalty programs. Effective reforms could raise revenues to clean up legacy mine waste and further augment needed supplies of critical minerals. Some materials recovery may require novel processing that needs more research and development support. Abandoned mine lands sites in particular provide an opportunity to augment critical mineral supplies, while cleaning up and remediating legacy pollution from past mining activities. Unfortunately there has been a historic lack of interest for among other reasons, there is little information about the composition and potential value of most of these legacy wastes.

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[1] https://www.epa.gov/greenerproducts/photovoltaic-modules-and-inverters

Materials recovery in mining and downstream processing 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 smelters that can recover cobalt in the United States.

There are also excellent examples of resource efficiency avoiding significant amounts of materials. A photovoltaic module today, thanks to increased resource efficiencies, uses about five times less silver than a photovoltaic module today. Similar, semiconductor wafers in the same technology are two to three times thinner than just a decade ago. This has translated to lower energy inputs and silicon feedstocks needed for the solar industry.

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. Advance materials science, input substitution, and alternatives to hard rock mining**

It is fundamentally important to emphasize incentives and policy that develops substitutes and alternatives to critical minerals 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 their popular and inexpensive Seagull 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.

We are also using many of these critical minerals in ways that make it difficult or expensive to recover germanium and gallium for example 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.

Supply chain diversification also means supporting alternative mining methods. While might be too early to characterize environmental impacts, the prospects of direct lithium extraction seems to offer significant benefits over hard rock mining for lithium.

## 5. Strengthen Tribal consultation

The energy transition is likely to be significantly impactful to Native American tribes. Most mining activity in the United States is in the American West, and within close proximity to Native American communities. 79% of lithium mining claims, 89% of copper, and 97% of nickel deposits are within 35 miles of a Native American reservation. Furthermore, the Bureau of Land Management has an obligation to conduct prior consultation on projects proposed across public lands because of important sacred sites off-reservation on their ancestral territories.

Mining activities puts both drinking water, cultural resources at risk, making it of the utmost importance to ensure community acceptance and respect for tribal sovereignty and cultural resources. I have read many public comments and spoken with representatives from Tribes over the years in my research and it is not uncommon to hear that the federal consultation process for National Historic Preservation Act to take one example is "failing tribes" on adequate and meaningful consultation.

Instead of looking for ways to short circuit environmental and cultural resource review—by undermining nation-to-nation consultation or expediting review—the United States should strengthen Tribal consultation in the National Environmental Policy Act around the ideas of self-determination and "Free, Prior and Informed Consent" as described by International Labour Organization's Convention number 169, the United Nation Declaration on the Rights of Indigenous Peoples. There is often emphasis on how the United States' mining practices are the best in the world because they have the strongest global regulations. But the issue of Tribal consultation needs significant improvement to catch up with international norms and standards on relations between mining activities and Indigenous peoples.

## 6. Reform the 1872 mining law

The 1872 mining law makes mining the highest and best use of public lands and reflects a time long since passed. The exploratory claims-based system is outdated, with most other parts of the world having lease-based systems that are more competitive and result in better decision-making on land uses.

Reform to the royalty system would benefit taxpayers, given there are no royalties for hard rock mining under the law today. Reform of the royalty program could raise substantial revenues to help finance the clean up and remediation of legacy mine pollution.

Mining law needs a better plan to pay for remediation of old mines. The 1872 mining law set the bar too low for bonding mine sites for reclamation and cleanup. The Government Accountability Office (GAO) estimates that federal agencies spent $2.9 billion in the decade from 2008 to 2017 on cleanup activities, and this could cost taxpayers up to $54 billion to clean up the nation's 400,000 to 500,000 abandoned mine sites that pose hazardous threats to communities.

The Initiative for Responsible Mining Assurance (IRMA) could be a model for reforming the 1872 law. IRMA allows for independent audits of mines to ensure environmental and social performance. Even the White House refereed to IMRA as a "method for U.S. companies and the Federal Government to ensure that minerals are being sourced from mines with robust environmental, social, and financial responsibility policies."[2]

The 1872 law was intended for settler colonialism on the western frontier not for mining in a modern high-tech economy. Federal and public lands should not be new sacrifice zones for decarbonization. Without key reforms, the antiquated mining law will continue to cause unnecessary environmental degradation and environmental inequality.

## 7. Avoid unnecessary groundwater and ecological impacts

The impacts of mining to water resources and riparian habitat across the United States cannot be understated. According to an analysis from Trout Unlimited, "half of the known critical mineral deposits in the U.S. are within trout and salmon habitat, and one in ten deposits are in protected public land areas like wilderness."[3] The same report notes that many critical minerals overlap with sage grouse habitat and major big game wildlife corridors. Rhyolite Ridge is a lithium mining project proposed by an Australian mining company that will impact Tiehm's buckwheat (*Eriogonum tiehmii*), a species that only exists on that particular site.

Across the American West, impacts to groundwater are of particular concern. Groundwater depletion can easily occur from over-pumping. The recently permitted Thacker Pass mine will use 2,500 acre feet per year for 41 years, which is about 104,000 acre-feet of water total, posing threat to the Kings River aquifer. There are several new gold mines under development and proposed in Nevada not far from Death Valley National Park, that are using substantial amounts of water, including one mining operation that will use water from a spring in the park, which receives about two inches of rain per year.

In Amargosa Valley near the Ash Meadows reserve, an exploratory lithium development project was almost allowed under that 1872 law to drill 30 boreholes without any environmental review,

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[2] The White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100-Day Reviews Under Executive Order 14017*, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf
[3] https://www.tu.org/cmr-a-path-forward/

within 2,000 feet of springs that are critical habitat for the endangered Ash Meadows Amargosa pupfish. If not for the community and an environmental group recognizing the BLM mistake, this critical habitat could have been comprised by a speculative venture.

As far as alternative extraction techniques go, we also at this point do not have the full picture of the groundwater impacts from Direct Lithium Extraction for example in the Salton Sea area, where several pilot projects are underway.

Public policy efforts to develop critical minerals should do so responsibly and should not undermine bedrock environmental laws. Predictability to developers is often the emphasis when describing environmental oversight, but predictability is also important to environmental groups and tribes to know what land is protected, and that there are community safeguards like strong environmental rules and opportunities for public participation.

## 8. Strengthen environmental review

The need to prioritize development of domestic minerals supplies should not undermine meaningful environmental review. In my experience, conservation groups, Indigenous peoples, and local communities feel that environmental review, even where an environmental impact statement might be required, is a foregone conclusion. Many communities view the NEPA process as a “decide-announce-defend” development strategy where developers and investors decide where they want to propose a project, announce it to the public, and then spend the review process defending the project.

Instead, more collaborative approaches are shown to be effective at gaining community support and trust. Transparent and meaningful public participation processes should result in responsible mine development and reduced community opposition to new mines.

It is often claimed that it takes 7 to 10 years or more to permit a new mine. The reality is the time to permit a hard rock mine is two years according to the GAO. The GAO did find variation with some mines taking up to eleven years, but their interviews with agencies and mine operators found delays were overwhelming caused by the applicant. More broadly, another GAO report found only 1% of NEPA covered projects need an Environmental Impact Statement. Only 5% of covered projects require an Environmental Assessment, a shorter environmental disclosure document that typically is completed in nine months or so.

There have been recent changes that promise to address any lingering NEPA issues. The IRA made the FAST-41 Act permanent, extended the provisions of the law to mining, and provided significant funding for agencies to process permits.

Thacker pass for example initiated the NEPA process in 2020 shortly after they submitted an operating plan to the BLM and is under construction today, despite being incredibly controversial.

To build infrastructure projects getting community support in a collaborative way is important. Finding a way to get communities, NGOs, and Tribes involved from the start can help ensure the community accepts and gives consent to the project, an makes it more likely benefits from the project recirculate in the community.

Some are concerned that the funding available through the IRA will be undermined by environmental review and make it difficult to spend all of the money. Lessons from the American Recovery and Reinvestment Act projects are a great example of how projects can be built on time. None of the $90 billion in clean energy projects missed deadlines because of environmental review. This includes large scale solar and wind facilities, a nuclear power plant, and photovoltaic, electric vehicle, and battery manufacturing plants. Concerns that IRA projects will be stopped by environmental review are overblown.

**9, Provide community benefits**

Where mines will be developed, bringing community benefits to the table will be important tools for public support, buy-in, and trust. Furthermore, to reap more community benefits, more value added industries to support the development of critical minerals supplies can ensure more jobs and local revenues are generated. Mining tends to have a very low value added without these downstream manufacturing activities.

Community benefits should be broadly construed to benefit as many as possible. The widely celebrated community benefits agreement between Lithium Americas and Thacker Pass and the Fort McDermitt Paiute and Shoshone Tribe is a one example worth looking at closely. While benefits accrue to some communities from this project, other tribes with ancestral claims to the landscape such as the People of Red Mountain feel their voices were not acknowledged and will receive no benefits.

Other examples that could be a model for how to build in community benefits is the approach used in the Salton Sea and suggested by the Blue Ribbon Commission on Lithium Extraction in California. That process is early on, but will be worth watching closely.

Community benefits will help gain local acceptance and collaboration with project development.

**Conclusion**

To conclude, securing supplies of critical minerals is essential to national security, domestic industries, and decarbonization efforts. More emphasis on diverting waste flows that contain critical minerals from landfills to supply chains will encourage a circular economy in materials that results in less waste, fewer greenhouse gas emissions, the development of domestic industries, and the reduction of risks and exposures to vulnerabilities in global supply chains.

We need to move beyond the “take-make-waste” cradle-to-grave management approach to critical minerals and create a circular economy based on practices and policies to encourage us to “make-use-recycle” in a cradle-to-cradle framework.

I appreciate this opportunity to offer these remarks and I look forward to the oversight hearing.

Sincerely,

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