Julia Neilson is changing the way copper mining companies think about the life cycle of their operations, especially in minimizing impacts on the environment and local communities.

Neilson is director of the Center for Environmentally Sustainable Mining, which brings mining companies, consultants and businesses together on a technical advisory committee that collaborates with campus experts to study how to improve and plan for more sustainable reclamation and restoration procedures.

"The decision to mine a particular ore body and the way mines comply with regulations around cleanup and closure are driven by a broad range of economic and engineering factors," said Neilson, who also is an associate research professor of environmental science. "We want to make sure environmental impact is included at every decision point in the process."

Founded in 2011 as a public-private partnership, CESM develops educational and research initiatives that address environmental issues related to mining.

The center worked with its partners on the advisory committee to produce the Collaborative Industry-University Research Initiative model. Developed with assistance from the University's contracting office, the new model enables researchers to tackle a particular real-world problem posed by at least three mining companies. Each company pays an annual fee for participation and gives researchers, including postdocs, graduate students and undergraduate students, access to its property for multiple years to conduct on-site fieldwork.

All industry and academic partners also gather in annual on-campus research forums to share and discuss findings and their application to management practices. The Revegetation Research Collaboration, the first project under the new model, currently includes ASARCO Grupo Mexico Mission mine, KGHM Carlota Copper, Rio Tinto Resolution Copper and BHP Inc.

The particular challenges of mining copper

Historically, copper mining companies have focused on maximizing the efficiency of extraction rather than on cleanup and closure. "The role the University can play," Neilson said, "is to research how companies can mine copper in the most sustainable way and delineate the environmental parameters that influence the relative environmental risks associated with mining different ore bodies." Her team's first project focuses on the challenge of getting plants to grow on large swaths of processed mine waste.

Unlike coal, another commonly mined ore, the concentration of copper within the rock surrounding it is low, often less than 1% of volume. Accessing copper, therefore, causes large-
scale land disturbances and results in large amounts of waste rock? rock from which no copper was extracted? as well as processed tailings. Tailings consist of rock that has been pulverized to a consistency of fine powder during the extraction process. After extraction, the powdered slurry is pumped into containment dams, some covering an expanse as large as 400 square acres and as deep as 160 feet, roughly equivalent to 300 football fields stacked 16 stories high. These artificial plateaus are capped with soil dug on-site from what are known as "borrow pits" to control dust and facilitate revegetation.

The difficulty of accessing the ore from the surrounding rock and the growing global demand for copper contribute to the massive size of these tailings dams, which become prominent features of the landscape.

The long, complex relationship between copper and culture

"Transmitting electricity requires copper and, at this point, there simply is no substitute," Neilson said. "Without it, we have no electricity, no computers, no cellphones, cars, jets or everyday appliances we've come to rely on. Modern life depends on copper."

Copper is so useful that humans have mined it for hunting, cooking, building, ornamentation and other uses for more than 10,000 years. Today, because of its unique role in our economy and because most copper already in use is "locked up" in existing built structures, rising demand can only be met by more mining. That means more disturbed land.

Working to restore the land after a mine closes and researching ways to reduce environmental impacts on new mine sites is complex, both legally and, in the Southwest, culturally. Here, the ore is often found and mined on tribal lands. For Lydia Jennings, a University of Arizona doctoral student working with CESM and a member of the Pascua Yaqui and Huichol tribes, seeking ways to minimize the environmental impact of mining is about much more than gathering data.

"It is critical that Indigenous people have a voice at the table," Jennings said, "That's why CESM's mission is important to me. By understanding the science as well as the legal and cultural implications of mining, revegetation, reclamation and restoration, I can amplify indigenous voices."

Jennings is involved in the CESM study at the ASARCO Grupo Mexico Mission Mine complex in Sahuarita, south of Tucson, where tailings dams can be found on mine property and leased Tohono O'odham land. When starting the reclamation process, ASARCO Grupo Mexico heeded input from the O'odham Environmental Protection Office and followed specifications from mine management so that the soil cap and the seed mixture were different at each location? a 12-inch soil cap was planted with 34 local seed varieties on O'odham land and a 6-inch soil cap was planted with 10 seed varieties on mine land. Comparing the two sites' revegetation progress is yielding valuable data for future restoration efforts.

As CESM's public-private partnership expands to address new research questions, the University's input in shaping the future of environmentally sustainable mining will expand, too. And as global demand for copper continues to increase, Neilson said, environmental sustainability will be more important than ever.

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