The Economic Impact of the Proposed Copper World/ Rosemont Mine Complex on the Greater Tucson Area Economy

Prepared for

Save the Scenic Santa Ritas

by

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Executive Summary

This report was commissioned to analyze the socio-economic impact of Hudbay's proposed Copper World/Rosemont Mine Complex mine in the greater Tucson area.

Making a rational economic decision about whether Hudbay's Proposed Copper World/Rosemont Mine Complex will help or hurt the area's economy

Hudbay Minerals Inc.'s overriding financial interest is to make the Copper World project profitable and attractive to investors. Conversely, the local community, herein referred to as Pima County or the greater Tucson area, is concerned with whether the mining operation will benefit the community overall. Analysis by local political leaders, businesses, labor, non-profits, and citizens at large typically considers not only the direct economic benefits from the mine, but also costs to economic drivers that include recreation, tourism, health, and the housing market. If the proposed mine's benefits to the greater Tucson area are outweighed by the costs, then the community's rational economic decision would be to oppose the mining project. This report explores the economic facts that would form the basis for such decisions.

As the report details, overall, the Copper World project would contribute minimal economic gain to the greater Tucson economy, while destroying the northern half of the Santa Rita Mountains and threatening human health and water supplies. The mine would damage economic sectors much larger than mining, including outdoor recreation, tourism, and the housing market. The project would create a barrier to people who otherwise might move to the area for its natural and cultural amenities.

I. Tucson Area economy is strong and resilient

The greater Tucson area has a strong and resilient economy with a large service industry and a significant amount of non-labor income. During past national recessions the local economy either continued to thrive or quickly made up the slight losses incurred during a recession. Many people have moved to Pima County over the past 50 years because of the favorable climate and cultural and recreational amenities. These include access to national parks, state parks, national forest land, a long, paved bicycle and walking trail throughout Tucson, designation of Tucson as a UNESCO City of Gastronomy, and a mixing of many different cultures and traditions.

Because so many people are moving here with accumulated wealth, including retirement savings and investments, per capita income is growing at a much faster rate than average wage compensation, growth that has contributed to the area's resilience during recessions. Because the 5,000-plus newcomers arriving per year need homes, during the 2000 to 2010 decade Pima County's residential acreage increased twice as fast as the national average.

If people keep moving in at the same rate over the planned 20-year first phase of the mine, the number of new people arriving would be nearly 128,000. This is 37 times the 430 direct and 3,000 secondary jobs that Hudbay claims it would create. If only 2.7% of these 128,000 people choose not to move to Pima County because of amenities lost due to the mine, this would offset all projected direct and secondary jobs.

II. Limits of the traditional economic base view

The traditional economic base consists of industries that produce raw materials for export, like mined metal and agricultural products, or else finished products like textiles and refined food products. At one time some of the biggest drivers of the greater Tucson area's economy were known as the five C's: copper, cattle, cotton, citrus, and climate, the first four forming part of the traditional economic base.

However, in the period from 1970 to 2000, service-related jobs became dominant and rose from 54.2% to 65.9% of the Pima County economy, while non-service jobs, which include copper mining, cattle raising, and growing cotton and citrus, dwindled from 20.4% to 16%. So, relatively small percentage changes in the dominant service sector can have outsized effects on the overall economy.

Even in the past when the mining industry formed a larger share of the overall economy in terms of jobs and consumption of local goods and services, most of the money generated did not remain in the community. Typically, mining companies, which may be national, foreign, or multi-national, take their profits out of the area, while the community is left with the costs associated with environmental degradation.

Moreover, once a mine is played out and closed, the mining jobs disappear. As a result of this pattern, many traditional mining districts around the country and within the state of Arizona have been persistently poor economic performers compared with similar areas without mining.

Comparing about 100 mining-dependent counties across the U.S. with non-mining counties, from 1980 to 2010 mining-dependent counties' earnings grew at only two-thirds the rate of non-mining dependent counties, personal income grew at three quarters the rate, and population and per capita income grew at about 88%.

III. Copper World is unlikely to be essential for the U.S. Green Energy Transition

Hudbay has publicly stated that copper produced by the Copper World complex will be important for aiding the national transition to green energy. But this mine is unlikely to be essential for U.S. copper needs because copper is not in short supply. It

is mined and processed in many countries, including many with whom the U.S. has free trade agreements.

The U.S. Geological Survey (USGS) has not listed copper as a critical mineral because the United States is the world's fourth largest producer of copper and has access to additional copper from major producing countries including Chile, Mexico and Canada with Free Trade Agreements. The USGS also notes that recycled copper alone supplies more than 30% of domestic copper demand. Analysts have concluded that over the next five to 10 years copper suppliers will be able to cover the demand with available mines and available technology.

Although the U.S. Department of Energy included copper in a report analyzing many critical materials in July 2023, the report concluded that copper is neither currently critical nor critical in the medium term through 2035.

IV. Analysis of economic benefits from the Copper World project

1. **Plans to produce finished copper delayed to at least year 5**
   In both the 2022 PEA and 2023 PFS, Hudbay stated that it plans to mine on both the east and west sides of the Santa Rita Mountains, place tailings piles near residential areas on the west side, and route truck traffic northwest across unpaved Santa Rita Road through the Santa Rita Experimental Range.

   Hudbay's 2022 Preliminary Economic Analysis (PEA) stated the mine would produce finished copper onsite that would be sold in the United States. However, in its 2023 Pre-Feasibility Study (PFS) Hudbay changed its plans and stated that during at least Copper World's first four years of operation it will not produce finished copper but only raw copper concentrate for export.

   Copper concentrate is a mix of finely-ground copper and other elements that Hudbay will export to overseas smelters and refineries because there is not enough capacity in the U.S. Beginning in year five of the project, Hudbay claims that it will begin refining some ore to pure copper on-site, while still exporting a sizable quantity of raw copper concentrate overseas.

2. **Volatile copper prices create economic uncertainty**
   Market demand and supply determines price, which determines production, which in turn would determine the mine's employment and economic contribution to the county. Typically, when the market price goes up, production, jobs, and income taxes all go up. Hudbay's economic projections assume a break-even world market price of $3.75 per pound, below which it would not be profitable to mine.
   The below graph, which displays copper prices converted to constant 2022 dollars, shows that from 1990 to 2023 prices have been extremely volatile, ranging from a low of $1.06 per pound to a high of $5.91 per pound, with an

average of $2.91. Just looking at 2010 on, copper has been below the $3.75 threshold about 52% of the time.

3. Analysis of Hudbay's employment projections

In its 2023 Pre-Feasibility Study, Hudbay projected that 430 miners will be directly employed at its proposed mine and ore processing facilities and that 3,000 secondary jobs will be created. However, studies on other mining communities, including those near the proposed Resolution Copper Project, indicate that Hudbay's 430 mining jobs would likely create significantly fewer than the 3,000 secondary jobs claimed.

Mining pay per worker will be higher than the average pay in Pima County. However, it is unclear how many of the miners will actually come from Pima County, since the jobs may attract miners from other areas of the country. Even assuming that Hudbay's projection of 3,430 total jobs is correct, employment from the proposed mine will only add tenths of one percent to the local economy. The number of mine-related jobs will ultimately be dependent on the amount of production, in turn dependent on market demand and price of copper.

Even assuming that Hudbay's projection of 3,430 total jobs is correct, employment from the proposed mine will only add tenths of 1% to the local economy. The number of mine-related jobs will ultimately be dependent on the amount of production, in turn dependent on market demand and price of copper.

The historical volatility and periodic lows in copper prices call into doubt Hudbay's assertions that its activities will continuously employ 430 miners and create 3,000 secondary jobs for 20 years. During periods when the market price falls below the mine's break-even price, the number of mining and indirect jobs are likely to fall.

4. Analysis of Hudbay's tax payments

Hudbay claims it will pay $12.35 million per year in property taxes, which would be slightly less than 1% of Pima County's total intake of property taxes. Roughly half would go to education, of which a portion would be spent in other counties under the state's equalization policy to ensure that school funding is equitable across the state.

Hudbay states it will pay $8.4 million per year in state taxes over the initial 20-year Phase 1 of the mine, representing 0.03% of Arizona's 2022 tax revenues of $27.8 billion. Payments to the federal government are projected to be $43

million per year, some 0.009% of the $4.9 trillion in federal income taxes collected 2022.

VI. Economic values at risk from the Copper World project

The proposed mine has the potential to negatively affect important industries that depend on Pima County's natural environment and/or groundwater, notably tourism, outdoor recreation, the housing industry, and agriculture. The harm to these industries could easily offset whatever economic benefits the mine would contribute in the form of jobs and tax payments.

1. Degraded natural landscapes and public lands

The outdoor recreation industry in Pima County annually generates $1.4 billion and employs more than 14,000 people. The mine would only directly employ 430 people, 3% of the number of recreation jobs.

By degrading the natural environment and blocking access to the Santa Rita Mountains, the mine will harm the outdoor recreation industry. Loss of recreation opportunities may decrease net in-migration. If the mine decreases the outdoor recreation industry and/or decreases the number of people who want to live in the greater Tucson area, that loss will offset some or all of the economic benefits of the projected mining employment.

The mine will destroy known jaguar habitat and block one of the most important wildlife corridors in the United States, a corridor that jaguars and other rare species use to move back and forth between the Santa Rita Mountains, other "Sky Island" mountains across Southeast Arizona, and Sonora, Mexico. The extremely high biological diversity of the Sky Islands, including jaguar, ocelot, and a high concentration of bird species, attracts people to Pima County and helps support the outdoor recreation industry.

One important contributor to the natural landscape is the Santa Rita Experimental Range (SRER), owned by the Arizona State Land Department and managed by the University of Arizona. The SRER is required by state law to operate for "ecological and rangeland" purposes as well as placing "state trust lands with high public value into public ownership where their special natural resources can be protected and managed for the general public."[1] The heavy truck traffic passing through the SRER on its way to and from the mine will disturb natural animal behavior and conflict with the ecological and rangeland purposes of the SRER. Hudbay's plans to place millions of tons of toxic tailings immediately adjacent to the SRER will compromise its pristine ecology.

2. Increased heavy truck traffic

Hudbay's mining plans indicate that heavy trucks will make more than 100 round trips each 24-hour period between the mine processing operations on the west side of the Santa Rita Mountains and the East-Sahuarita-Road-and-Interstate 19 interchange. The truck traffic will include copper concentrate and industrial supplies, including hazardous chemicals needed to operate the mine.

This industrial truck traffic will cut northwest through the 52,000-acre Santa Rita Experimental Range (SRER) on unpaved Santa Rita Road, passing by the community of Sahuarita Highlands, and will then take East Sahuarita Road through Sahuarita to Interstate 19.

Concerns include dust, possible collisions between trucks and passenger vehicles, spills of copper concentrate, and possible spills of sulfuric acid when it is produced beginning in year five.

3. Competition for water

We deduce from information provided by Hudbay that water use at the beginning of the project is likely to be 6,000 acre-feet per year, the amount allowed by its current state permit. This is enough water to supply some 20,000 households. If Hudbay follows its current plan to start refining copper onsite in year five, it is likely to need a total of at least 13,000 acre-feet per year, enough for roughly 40,000 households.

The wholesale value of this water, depending on assumptions made, ranges from about $1 million per year to about $7 million per year for the 20-year life of the mine.

This water will be pumped from the same aquifer used by nearby communities like Sahuarita, Quail Creek, and Green Valley, substantially decreasing water available to farmers and residential housing, with concomitant impacts on the local economy.

4. Drops in property values

In Pima County, drops in home value in communities near the mine may collectively be far larger than income from projected mining jobs.

Property values near the mine will decline when aesthetically attractive views are replaced by an industrial landscape. Contaminated dust blowing from tailings piles is likely to reach residences, causing health concerns. Residents also may be concerned about water availability and quality. Heavy truck traffic passing through or by residential neighborhoods like Sahuarita Highlands may further dampen housing prices.

House prices in Corona de Tucson, the community closest to the mine, could drop more than $100 million due to the combined effects of air pollution and lost scenic vistas alone, while aggregated home values for the communities of Corona de Tucson, Sahuarita, Green Valley and Vail could drop between $355 million and almost $2 billion, depending on which methodologies are used for estimation.

5. Population growth and in-migration

The population grew 24% in Pima County from 2000 to 2021, substantially more than the national average, and in-migration contributed 78% of that population growth as more than 5,000 people per year on average moved into the county. The 5,000-plus people who move to Pima County in just one year is more than 10 times the number of workers that Hudbay will directly employ.

Many of these newcomers bring with them large amounts of non-labor income, such as retirement funds, rental income, and income from stocks and bonds. This non-labor income is a vital economic driver that generates nearly half of the county's income and helps support the dominant service-jobs sector.

Very small percentage decreases in net in-migration could cause loss of jobs in the service industry that alone could offset any economic benefits from the mine. For example, a loss of only 0.1% of service industry jobs would offset the mine's 430 direct jobs.

Full Report

I. Introduction

This report was commissioned to analyze the socio-economic impact of Hudbay's proposed Copper World/Rosemont Mine Complex [Copper World project] mine on the greater Tucson area. The report analyzes how the mine's activities would affect important industries like tourism and the housing market so that residents can make rational economic decisions as to whether the mine would provide a net benefit to the community overall.

By looking at historic trends in the greater Tucson area economy we can establish a baseline to understand how the mine might change the local economy. For example, the mine might draw some people to the area by creating direct and indirect jobs, but it might deter people who place high value on living near pristine natural environments. It is challenging to analyze how such effects play out, given the inherent complexity of a large, varied economy like Pima County's.

Such complex economies are composed of interdependent webs of economic services. Small changes in one sector of the economy have the potential to ripple through other sectors, including industries that may not at first glance seem closely linked to mining, like tourism, health care, and real estate.

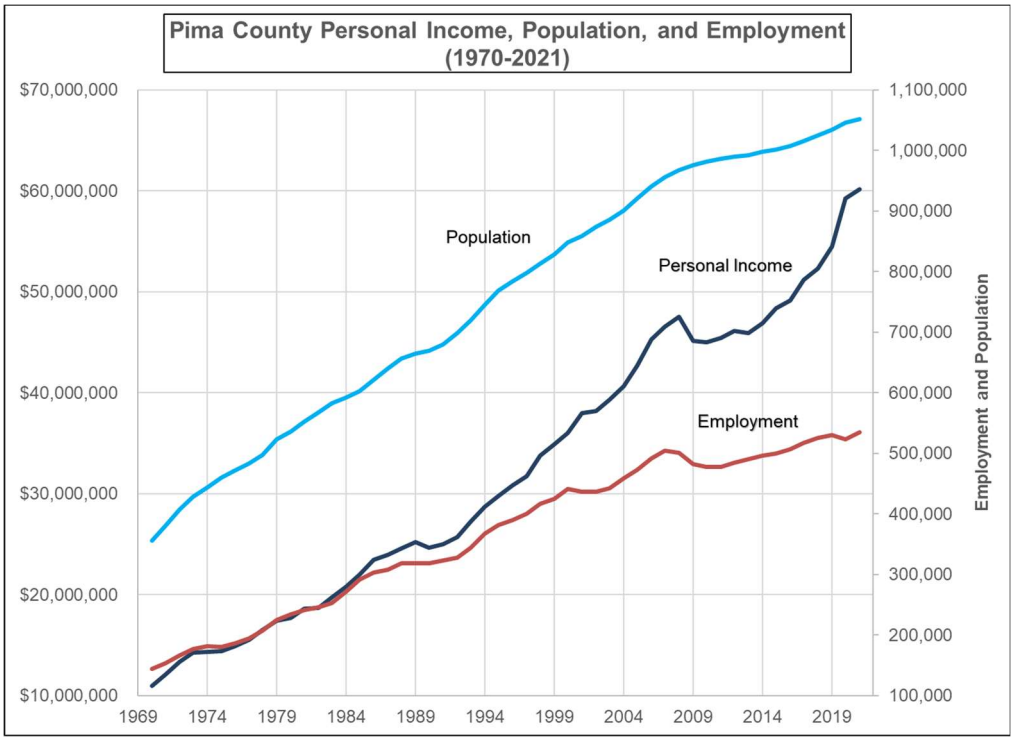
1. Vitality of the greater Tucson area economy

Pima County, Arizona, has the same geographical boundaries as the Tucson Metropolitan Statistical Area. That large urban area has been gaining population at a relatively rapid rate over the last half-century. Between 1970 and 2021, the population increased from 355,962 to over one million, a 196% increase.[1] Job growth over the same period, 1970 to 2021, increased at an even faster rate, a 271% increase[2] (see Figure 1 below.), and personal income increased, corrected for inflation, by 450%, far outpacing both population and job growth.[3]

Pima County has done remarkably well at weathering the five recognized national recessions that occurred during the last 50 years. After each recession Pima County was able to add significantly more jobs back than were lost during the recessions. In fact, during only two of the last five recessions (1980 and 2008), did Pima County, on net, lose *any* jobs.[4] The largest loss, in 2008, the most recent recession, was about 1,000 jobs. Since that time, Pima County has added more than 35,000 jobs, an increase of almost 35-fold compared to the jobs lost.

[1] Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. 6.7.2023.
[2] Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. 6.7.2023.
[3] Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. 6.7.2023.
[4] Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. Tab 14. 6.7.2023.

Figure 1.



The personal income in this figure is stated in real terms (2022 thousands of $s). Source: Headwater Economics. Economic Profile System: Pima County, AZ. 6.7.2023.

Figure 1. shows population, personal income, and employment in Pima County from 1970-2021. The left vertical axis shows total personal income in thousands of real 2022 dollars and the right vertical axis shows employment.

2. Patterns in non-labor income

Since 1990, Pima County has seen its population increase by 57.3%, compared to 33% for the U.S. as a whole.[5] Population can increase in two different ways: Population can grow because births exceed deaths, providing a "natural rate of growth." Alternatively, in-migration[6] may exceed out-migration so that *net* in-migration is positive. For Pima County, more than 80% of population gain since 1990 has been

[5] Headwaters Economics. Economic Profile System. Living Near Public Lands. Pima County, AZ. 6.20.2023.

[6] "Domestic in- and out-migration consist of moves where both the origin and the destination are within the United States (excluding Puerto Rico). The net domestic migration rate expresses net domestic migration during a time period as a proportion of an area's population at the midpoint of the time period." U.S. Census. State and County Terms and Definitions. Net Domestic Migration. Accessed 8.1.2023.

due to net in-migration and a little less than 20% associated with the natural rate of growth.[7] In other words, people are **choosing to move** to Pima County.

Many people who move to Pima County bring non-labor income, which includes returns on investments (dividends, interest, rents) and transfer payments (including government retirement and disability payments, insurance payments, as well as income support payments from government agencies to individuals and households).

Potential migrants with substantial non-labor income are freer to move to places like the greater Tucson area that they perceive as offering high quality of life, which helps explain why there is so much non-labor income in Pima County. Labor income and non-labor income are almost equal.[8]

The percentage of non-labor income in Pima County is significantly higher than in the U.S. as a whole, and Pima County has more non-labor income per person than other counties in the western U.S.[9] Non-labor income in 1970 represented about a third of Pima County residents' personal income, and in 2021 it had grown to almost half. This increase in non-labor income helps explain why personal income in Figure 1, below, grew at a higher rate than either employment or population.

In part this non-labor income reflects that so many older people with accumulated assets have been moving to the greater Tucson area. Between 2010 and 2021 the percentage of people 65 and older in Pima County increased from 15% to almost 20%.[10]

Although there is discussion in the economics literature about whether a high percentage of non-labor income can negatively affect a county's economy,[11] the above statistics demonstrate that Pima County's economy has been doing very well despite, or perhaps in part because of, the large amount of non-labor income.

To understand how the mine could affect non-labor income, it is essential to analyze who is moving to Pima County, why they are doing so, and what types of non-labor income they are bringing with them. A report by Headwaters Economics explained critical differences in the types of non-labor income:

> "Two examples illustrate why it is important to differentiate between types of non-labor income. In Teton County, WY, home of the resort town of Jackson, 79 percent of personal income is from Dividends, Interest, and Rent, an

[7] Headwaters Economics. Economic Profile System. Living Near Public Lands. Pima County, AZ. 6.20.2023.
[8] Headwaters Economics. Economic Profile System. Living Near Public Lands. Pima County, AZ. 6.20.2023.
[9] Headwater Economics. Across the West, Non-Labor Income is Large and Growing. February 2014. Accessed 6.7.2023.https://headwaterseconomics.org/dataviz/non-labor-income/
[10] Headwater Economics. Economic Profile System: Pima County, AZ. Demographics. 6.7.2023.
[11] Lawson, Megan M. & Rasker, Ray & Gude, Patricia H. The Importance of Non-labor Income: An Analysis of Socioeconomic Performance in Western Counties by Type of Non-labor Income. Journal of Regional Analysis and Policy, Mid-Continent Regional Science Association, vol. 44(2). 2014.

> indication that this town's economy is driven largely by the stock market. In contrast, in Lincoln County, MT, home of Libby, 58 percent of personal income (and 90 percent of net growth in the last 15 years) is from non-labor sources. But, in this county, non-labor income (NLI) consists primarily of age-related payments, such as Medicare and Social Security, and hardship-related payments, such as Medicare and welfare programs.
>
> While Jackson's economy is dominated by a growing tourism and recreation sector spurred by wealthy "amenity migrants" and second-home buyers, Libby's is characterized by an aging population and higher levels of economic hardship related to the loss of mining and timber jobs and the out-migration of the younger, working population. While in Jackson non-labor income stimulates the health care, retail and construction sectors, in Libby it likely only affects the health care sector."[12]

So, does greater Tucson population more closely resemble Libby or Jackson Hole? A strong indication that it is more similar to Jackson Hole is that "hardship payments" associated with poverty and welfare only made up about 10%of all personal income in Pima County in 2021.[13] Given the character of the non-labor income, the number of people that have been moving to the greater Tucson area, the growth in employment, and demonstrated the ability to weather national recessions, Pima County it is likely more similar to Jackson Hole than to Libby. We can surmise that, as with Jackson Hole, many of the people moving to Tucson are "amenity migrants" who are looking for benefits that could include a vibrant cultural scene, a welcoming climate, and outdoor recreation.

3. Patterns in labor income: the rise of service-related jobs

Between 1970 and 2000 a significant change occurred in the relative contribution of service-related jobs to the Pima County economy. During this period, service-related jobs increased from 54.2% to 65.9% of total jobs, while government jobs declined from 35.5% to 18.1% and non-service-related jobs[14] declined from 20.4% to 16%. In other words, service-related jobs not only made up for the decline in government and non-service-related jobs but led the county in employment growth.

By 2021 this trend was even more pronounced. The service-related sector supplied 72% of Pima County jobs, while government contributed 16% and the non-service-related sector had dropped to only 12%. See Figure 2, below, for changes in total

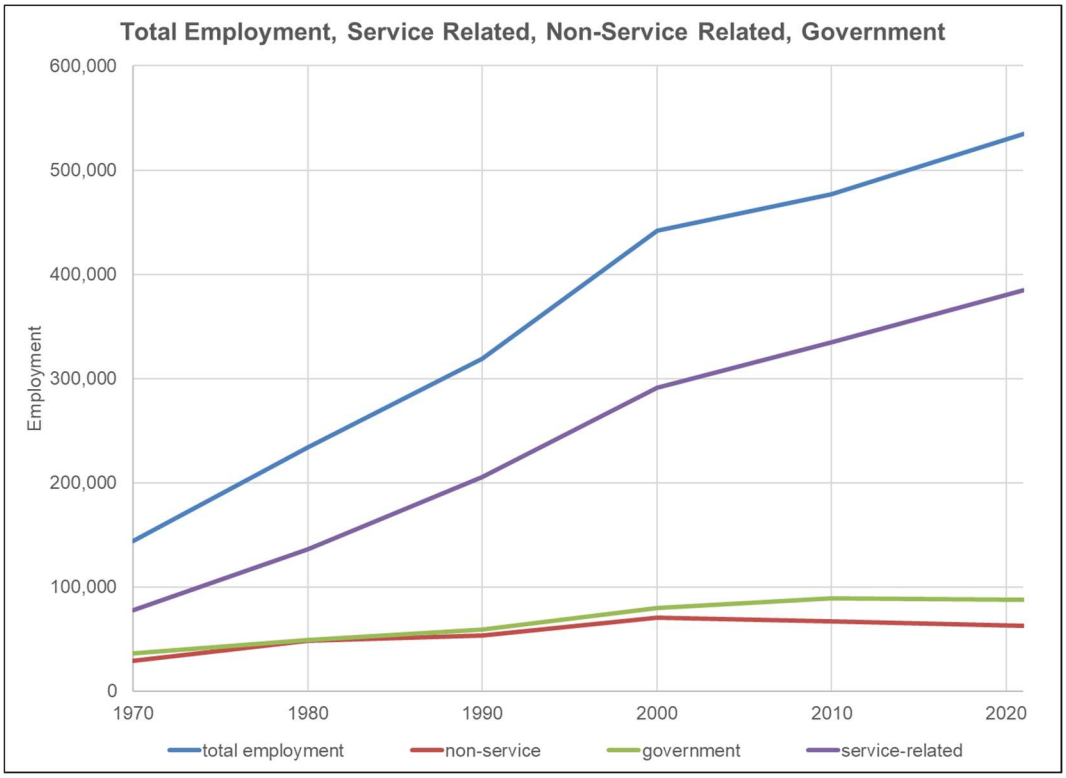
[12] Rasker, R. Economy surprisingly dependent on non-labor income. Headwater Economics. August 2017. Accessed 8.28.2023. https://headwaterseconomics.org/economic-development/trends-performance/economy-surprisingly-dependent-on-non-labor-income/

[13] Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. Tab 4. 6.7.2023.

[14] Non-service-related includes farm, agricultural services, forestry and fishing, mining includes fossil fuels as well as metal ores and other minerals, construction, and manufacturing including forest products.

employment, service-related employment, non-service-related employment, and government employment.[15]

Figure 2.



Source: Headwaters Economics: A Profile of Socioeconomic Trends. Pima County, AZ. 6.8.2023.

Figure 2. shows the rise and dominance of the service-related-sectors of the economy between 1970 and 2021. This is a trend that is evident in many different cities in the western U.S. While some sectors, such as the farm sector, have remained relatively constant at about 1,000 jobs, in Pima County over the last 50 years, the relative size of the agricultural sector has gone down significantly as the overall Pima County economy grew much faster than the agricultural sector.

Mining has followed the pattern of other non-service-related industries, dropping from almost 5% of all Pima county jobs in 1970 to a little less than 1% in 1990, to 0.6% in 2021. This decline was most dramatic between 1970 and 1987, when mining lost almost 6,500 jobs, about 75% of the 1970 number. Subsequently, the total number of mining jobs held relatively constant while the rest of the Pima County economy has

[15] There is an apparent inflection point at the year 2000 in Figure 2. This is an aberration that exists because the national classification system of industries changed the way that it classified many different industries. Most economists will only present pre-2000 data together and post-2001 data together, but it is more powerful to present the longer historical period.

continued to grow, with most service-related industries, like transportation and warehousing, increasing the number of jobs by double digits percentages between 2001 to 2021.[16]

Clearly something other than land-based commodities like mining and agriculture has been attracting and supporting new residents and expanded economic activity.

4. The growing importance of quality of life in determining economic activity

Economic observers have identified extensive net domestic migration into Pima County over the last several decades as a major foundation of the county's present economic vitality. As described above, many of these "migrants" bring with them substantial assets that become major drivers for the economy.

Although many of these migrants are older people who contribute little to the birthrate and have a high death-rate relative to younger cohorts, the level of in-migration is high enough to more than offset the number of people dying, with resultant net increases in the overall Pima County population.[17]

The University of Arizona has used data on the migration of residents among the fifty states to determine how attractive each state is to migrants from some other state. In 2015, Arizona was ranked in the top 10 of American states in terms the perceived standard of living migrants found in each state.[18]

Although Pima County's strong job market will attract some migrants, many people moving to the Tucson area are retired or gain their income through means not tied to a particular location, for example distance workers in the IT industry. Such people could essentially live anywhere, so why Tucson?

One reason is the warm climate and the many sunny days per year, as referenced in the phrases "the sun belt" and the "Arizona sun corridor." Part of this attraction is undoubtedly that the good weather allows people to enjoy Arizona's biologically diverse wildlands for hiking, birdwatching, and other outdoor recreation. Other "quality of life" factors that draw people to Pima County are cultural events, a thriving

[16] Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. Tab 6. 6.7.2023.
[17] "The net domestic migration for a given geographic area is the difference between in-migration (the number of people moving in) and outmigration (the number of people moving out) during a migration period. We typically measure migration from July 1 of one year through June 30 of the next (e.g., July 1, 2020, to June 30, 2021, represents the 2020-2021 migration period)." Toukabri, A. et al. Net Domestic Migration Increased in Many U.S. Counties in 2021. 3.24.2022. https://www.census.gov/library/stories/2022/03/net-domestic-migration-increased-in-united-states-counties-2021.html#:~:text=The%20net%20domestic%20migration%20for,out)%20during%20a%20migration%20period.
[18] Hammond, G. Ranking Arizona: Income and Quality of Life. Economic and Business Research Center, University of Arizona, Exhibit 3, p.8. *Arizona's Economy.* 9.12.2017.

food scene, a music scene, green spaces and mountain vistas close to their homes, readily accessible bike and hiking trails, and nearby national forest lands and the Saguaro National Park.

Recognizing people's desire for outdoor recreation, Pima County has heavily invested in a 137-mile paved bike and walking trail called The Loop that tours the City of Tucson and attracts half a million bikers per year.[19]

Many objective sources attest to the Tucson area's outstanding attractiveness:

- In 2023 the *New York Times* named Tucson one of the 52 places in the world that their readers should visit for art, architecture, culture and history.[20]
- In 2023, *Travel and Leisure* magazine ranked Tucson as number 6 among the best food cities in the U.S.[21] because it is the first U.S. city to be named a UNESCO City of Gastronomy,[22] and has a mix of Native American and Mexican cuisine, locally sourced food with unique ingredients, and a wide variety of restaurants and bars.
- *Outside*, an outdoor recreation magazine, in 2019 named Tucson one of "The 12 Best Places to Live."[23] *Outside* noted neighborhoods with access to long bike paths, mountains to climb, and mountain bike adventures.

We provide more detail in Section V.1 on specific amenities that bring people to live and stay in Tucson.

II. Limits of the traditional economic base view

The *economic base* of an area refers collectively to those industries that produce tangible primary products (commodities) for markets generally outside the area, industries like mining, logging, and farming. Hudbay, for example, plans to export copper concentrate outside the U.S. and perhaps, in time, pure copper to other regions of the U.S. Hudbay's operations, therefore, would be considered part of the economic base. Also considered part of the economic base are finished products manufactured for export, such as machinery, household equipment, and processed foods.

Historically, Pima County's economy depended heavily on this "economic base," including mining, while secondary economic activity that produced goods and

[19] Pima County. The Chuck Huckelberry Loop. Accessed 8.3.2023. https://www.pima.gov/162/The-Chuck-Huckelberry-Loop and Pima County. Loop Usage Reports. Accessed 1.8.2024. https://www.pima.gov/248/Loop-Usage-Reports
[20] New Tok Times. 52 Places to Go in 2023. https://www.nytimes.com/interactive/2023/travel/52-places-travel-2023.html
[21] Ellman, L. The Best Food Cities in the U.S.: From coast to coast, these are the best places to travel for foodies. Travel and Leisure. 3.19.2023. https://www.travelandleisure.com/best-food-cities-in-the-us-7254754
[22] City of Tucson. City of Gastronomy. Accessed 7.17.2023. https://tucson.cityofgastronomy.org/
[23] Outside Magazine. Editors. The 12 Best Places to Live in 2019: Presenting America's new adventure capitals. 7.11.2019. https://www.outsideonline.com/2398647/outside-best-towns-2019

services for *local* use could not by itself support local economic vitality. However, as described below in Section II.2, since 1970, "base" industries have made up a smaller and smaller percentage of the economy over time, overtaken by service-related industries, non-labor income, and non-extractive manufacturing.[24,25] Given that mining and some other "economic base" industries have been declining over the past decades, they have clearly not been major contributors to the growth of Pima County's robust economy during this time.

1. The Paradox of Mining: high pay and valuable treasure, but little prosperity

In this section we look at how mining in general affects the economies of nearby communities, and then, in the following section (II.2), we look` at how trends identified in this section play out in some Arizona communities.

Given the high wages associated with mining, one might expect communities that rely on mining to be unusually prosperous. In general, that is not the case. Across the United States, mining communities, as documented in the following paragraphs, are noted for high levels of unemployment, slow growth in income and employment, high poverty rates, and stagnant or declining populations. In fact, several of the nation's historic mining regions have become synonymous with persistent poverty, not prosperity: Appalachia (coal), the Ozarks (lead), the Four Corners (coal and uranium), and the Upper Peninsula of Michigan (copper and iron).[26]

There are two notable reasons that mining, including copper mining, has consistent and prolonged employment problems that we will discuss in detail below: 1) in the

[24] The "traditional natural resource economic base" includes manufacturing associated with *local* natural resources: food products, refined metal, wood products, paper, etc. High tech assembly of computer systems does not necessarily make use of local raw materials.

[25] The different categories into which different types of economic activities are divided by the official economic "bean counters," often are defined in a somewhat vague and, therefore, confusing terms. This is the case with the primary "dividing line" we have discussed here: goods production versus services production. Historically, manufacturing has been one of the more important types of "goods" production. Within contemporary manufacturing are many jobs that involve design, engineering, etc. Contrasted with this are manufacturing blue collar jobs associated with assembly lines. The former are often labeled "high tech" jobs that require "knowledge workers." The "blue collar" jobs often are depicted as workers carrying out repetitive physical tasks that require limited training and skills. This can be juxtaposed against white-collar knowledge workers quite similar to the experts guiding high tech manufacturing. One reason to distinguish these different types of "manufacturing" is the degree to which local operations depend on local raw materials.

[26] Outside of the rural U.S. deep south where a long history of racial inequality has led to persistent poverty, mining and other natural resource counties are prominent among the persistently poor non-metropolitan counties. Freudenburg, W. and Wilson, L. Mining the Data: Analyzing the Economic Implications of Mining for Non-metropolitan Regions. *Sociological Inquiry*, 72(4). Fall 2002. **For a more complete understanding of the "anomaly of mining" please see:** Power, T. Lost Landscapes and Failed Economies: The Search for a Value of Place. Island Press. 1996., Power, T. , and Barrett, R. Post-Cowboy Economics: Pay and Prosperity in the New American West. Island Press. 2001., and Power, T. The Economic Anomaly of Mining—Great Wealth, High Wages, Declining Communities. Chapter 3, p. 96 in *Mining in New Mexico: The Environment, Water, Economics, and Sustainable Development*, L.G. Price et al. eds. New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute on Mining and Technology. 2005.

U.S., productivity per mine worker continues to climb, which means that fewer workers are needed to mine the same amount of ore, and 2) production and associated employment depend on fluctuating international commodity prices. We begin by examining some of the economic data for mining-dependent counties in the U.S.

In order to explore how mining has affected local communities in the United States over three decades (1980-2010), we analyzed the economic performance of all U.S. counties where mining (excluding oil and gas extraction) provided 20% or more of labor earnings at some time in the 1980s. The start time, the 1980s, was not chosen for a particular reason other than giving us a long enough historical record to identify trends. We identified about 100 such "mining dependent" counties out of the 3,100 counties in the United States.[27] Data disclosure problems prevented the identification of some mining-dependent counties.[28]

The mining-dependent counties we were able to identify are spread over half of the American states but are geographically clustered in the Appalachian and Mountain West states. These counties hold:

1. The century-old copper mines of Arizona, New Mexico, Montana, Utah, and Upper Michigan
2. New gold mines in Nevada
3. New open-pit coal mines of Wyoming, Montana, Utah, Colorado, New Mexico, and Arizona
4. Older coal mines in the southern regions of the Great Lakes states (Illinois, Indiana, and Ohio)
5. Lead mines of the Missouri Ozarks
6. Precious metal mines in the Black Hills of South Dakota and the Silver Valley of Idaho
7. The iron fields of Minnesota and Upper Michigan

[27] The Regional Economic Information System 1969-2000 (Bureau of Economic Analysis, US Department of Commerce) was the source of the data. A county was included as "mining-dependent" if the data indicated that for at least one year in the 1980-1989 period "mining" less "oil and gas" earnings were 20% or more of total earnings by place of work.

[28] If a few firms dominated local mining, federal regulations prevent the release of the mining data for that county. This is often a problem in any given year, but it is less of a problem when looking at 20 years of data since mining data often will be available for at least one of those years and thus qualify it as "mining-dependent." The number of counties that would have been labeled mining-dependent if it were not for these data disclosure restrictions is unknown. However, our analysis identified about the same number of mining-dependent counties as other studies, about 100 counties dependent on solid minerals and another 100 dependent on oil and gas extraction. Kenneth Deavers and David Brown in a 1985 study identified a total of 199 counties in these two categories (Natural Resource Dependence, Rural Deavers, K. and Brown, D. Development, and Rural Poverty. Economic Research Service, US Department of Agriculture. Rural Development Research Report No. 48. 1985. A 1994 study identified only 146 mining-dependent counties (including oil and gas counties) (Cook, P and Mizer, K. The Revised ERS County Typology, Economic Research Service, Rural Development Research Report Number 89, US Department of Agriculture. 1994.)

We measured these counties' economic performance four ways: a) total income received by residents, b) aggregate labor earnings of residents of the county, c) per capita income, and d) population. In addition, we looked at the *level* of per capita income at the beginning and end of time periods analyzed. The relative economic performance of specialized mining communities can be compared to counties that did not specialize in mining by forming a ratio of the growth in the mining counties and the growth in the non-mining counties.

We found that mining-dependent counties' earnings grew at only two-thirds the rate of non-mining dependent counties, personal income grew at three quarters the rate, and population and per capita income grew at about 88%. Given this poor economic performance by mining-dependent counties despite the high wages paid by mining, it is not surprising to find that population growth in these counties was negative during the 1980s and significantly slower than the rest of the nation during 1990s and from 2001 to 2008.

For some states, such as Arizona and Virginia, coal-county unemployment rates are two to three times higher than the state unemployment rates. Even where mining persisted over long periods, it did not trigger a healthy diversification of the economy. Instead, as labor-saving technologies reduced the need for employees, mining areas typically became distressed with high unemployment and poverty.[29]

We can expect that copper mining would follow a similar economic path because of its fundamental similarity with coal mining. Both move massive volumes of material, mar the landscape with scars that are not economically feasible to remediate, use large amounts of water in preparation and processing, and typically provide less employment over time as ore reserves decline and mining technology becomes more efficient.

As efficiency increases, fewer workers are needed for the same output. In 1860 the amount of copper ore that one employee could mine in a year was slightly more than 1 tonne and by 2010 it was over 100 tonnes.[30] This is an annual growth in labor productivity of about 3% per year.

An annual increase in labor productivity of 3% means that a mine can cut its labor force by 3% every year while producing the same amount of copper. Historically, this 3% per year increase in efficiency has resulted in a huge loss of jobs. In 1974 Arizona

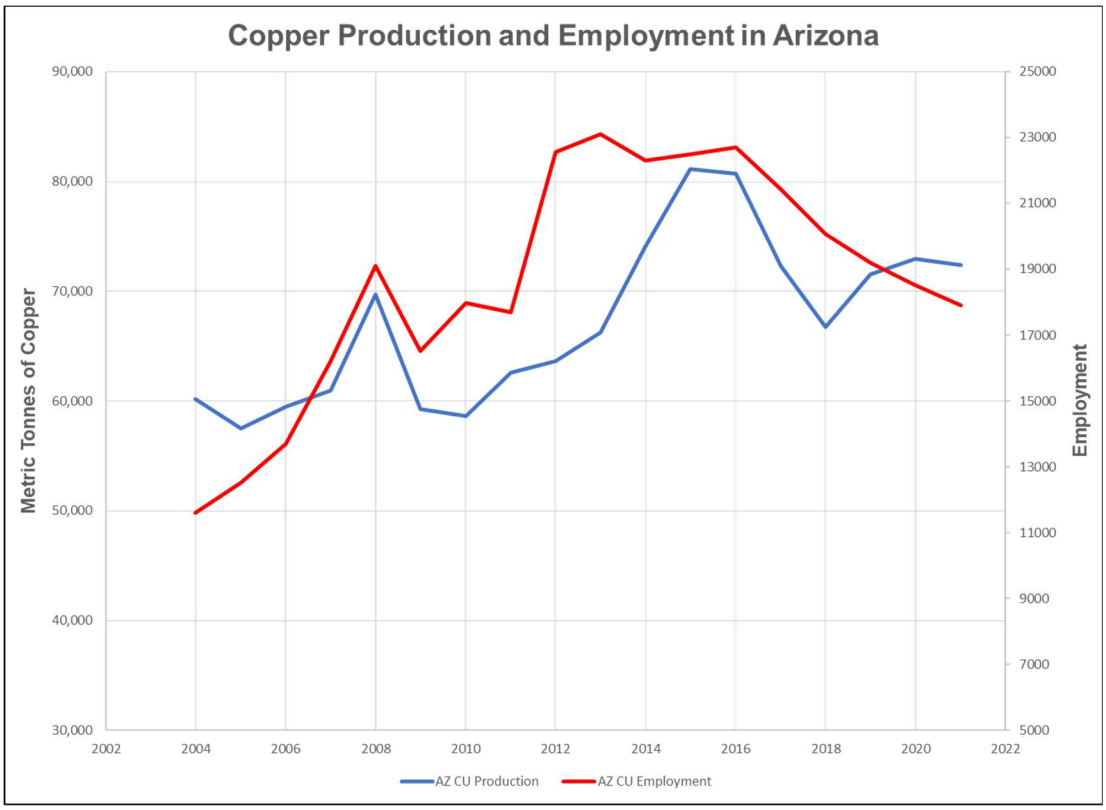
[29] A 2002 review of the literature dealing with the economic characteristics of mining-dependent rural communities in the US confirms these results. Of the 301 quantitative economic findings in scholarly studies about how mining-dependent communities fared relative to other communities, there were almost two (1.9) negative impacts reported for every positive finding. See **"**Mining the Data: Analyzing the Economic Implications of Mining for Non-Metropolitan Regions," William R. Freudenburg and Lisa J. Wilson, *Sociological Inquiry* 72(4):549-75. "Rural" is used loosely here to refer to non-metropolitan areas that can have urban areas with populations of up to 50,000.

[30] Humphreys, D. Mining productivity and the fourth industrial revolution. *Miner Econ.* **33**, 115–125. 2020. https://doi.org/10.1007/s13563-019-00172-9

copper industry employment peaked at about 29,000 workers.[31] By 2003 the number of copper industry jobs had tumbled to 5,900, a loss of four out of five jobs.

Since 2004, copper mining production and associated employment in Arizona has fluctuated in response to market demand.[32] When production increased from 2010 through 2016, employment increased because higher production required enough new workers to more than offset any jobs lost to more efficient technology. When production decreased, as it did between 2017 and 2021, employment likewise decreased.[33] See Figure 3, below.[34]

Figure 3.



Source: University of Arizona. Copper Production and Prices and Headwater Economics. Economic Profile System: Socioeconomic Indicators Arizona.

[31] Headwater Economics. Economic Profile System: Socioeconomic Indicators Arizona. Tab 5. 7.7.2023.
[32] Headwater Economics. Economic Profile System: Socioeconomic Indicators Arizona. Tabs 5,6. 7.7.2023
[33] Arizona experienced a slowdown in copper production between 2015 and 2018, but the overall trend from 2010 through 2023 is of increased production. It is possible that some of the employment associated with copper production in Arizona are also associated with exploration. University of Arizona. Copper Production and Prices. Accessed 8.29.2023. https://www.azeconomy.org/arizona-copper-production-and-prices/
[34] Note that this time frame and the fluctuating production does not lend itself to the much longer trends that we have been discussing of improvements in the productivity of copper production..

Figure 3 shows copper mine employment (red line) and copper mine production (blue line) in Arizona between 2004 and 2021. The general trend is that when more copper is being mined, more miners are employed. Because of international copper price trends (see Figure 4 below), the short time frame presented, and the time lag to adjust output to match copper prices and the development of new mines, it is hard to determine the impact of technological change in this figure. What is evident is that employment and production, in a short time frame, follow each other quite closely.

2. Trends in the economic contribution of mining to Pima County

Since mining is not a major economic driver in Pima County or the state compared to service industries and non-labor income, why is copper mining seen as being so important? The answer lies in Arizona's complicated history with copper mining.

In the last quarter of the nineteenth century, Arizona became an important supplier of copper to the U.S. Many of the original mining districts that were then developed continue to be mined today. These areas include the Morenci district in Greenlee County, the Globe-Miami district in Gila County, the Green Valley operations in Pima County, and the Bisbee area in Cochise County. We can review the economic histories of these and other mining areas in Arizona to draw conclusions about their economic effects.

We can compare areas with and without copper mining to evaluate economic vitality since 2000.[35] We can use Pima County for comparison to mining areas because its level of copper mining is small compared to the total economy. Pima County, when compared to the U.S. overall, saw an increase in population, similar levels of employment, much higher personal income, higher average earnings, and higher per capita income in percentage terms.

- In Greenlee County, home of the Morenci mine, population growth, employment, personal income, average earnings per job, and per capita income have all been below those for Pima County and the U.S. overall.[36]

- In Gila County, home of the Globe-Miami mining district, growth in population, employment, average earnings per job, and per capita income are lower than in both Pima County and the U.S. overall. Personal income in Gila

[35] The year 2000 is used as the starting date because in the year 2000 the federal government changed how it defined industry groups and how it derived the basic economic data e.g., employment, personal income, earnings, etc. These changes in data collection definitions led to estimates for the year 2001 that were not consistent with the earlier data ending in the year 2000. As a result, there was a discontinuity in the data between 2000 and 2001 that was an artifact of the new definitions and measurements. For that reason, economists often begin the historic economic data series using the year 2000 through to the current year.
[36] Headwater Economics. Economic Profile System: Socioeconomic Indicators Greenlee County, AZ. Tab 15. 7.7.2023.

County is *increasing* at a rate higher than the national average but lower than in Pima County.[37]

- Even within Gila County we can compare the Globe-Miami area, where there is a heavy concentration of mining, with the Payson area in the north, where there has never been significant mining. According to most economic indicators, the Globe-Miami area is not doing well. Despite paying high wages compared to other jobs, there has not been significant in-migration. In Globe, itself, between 1910 and 2020 its population fluctuated between just over 6,000 and just over 7,000.[38] The likely reason the population has remained flat is that most of the mine's profits were taken out of the area instead of recirculating to sustain local economic opportunities.

- Conversely, Payson, without significant mining, has grown much more than Globe. In 1970 Payson's population was only about 1,800 people, but by 1980 the population had almost tripled to 5,200, and by 2022 there were 16,653, more than nine times the number in 1970.[39] Payson, a non-mining town in a county with lots of mining, shows that areas without mining can thrive by playing up the *lack of mining*. In fact, Payson has purposely marketed itself as an outdoor paradise where "97 percent of the city is surrounded by lands under the jurisdiction of the United States Forest Service."[40] Payson is surrounded by forests, not copper mines. Of course, Payson also benefits from its high altitude, near 5,000 feet, making it much cooler than the Globe-Miami area, and its proximity to Phoenix, which makes it an attractive recreation destination.

3. The economic implications of environmental degradation

High quality natural and social environments contribute to local economic vitality by holding and attracting investors and residents, including retirees and others with high levels of non-labor income, encouraging a diversified visitor economy, and attracting business activity linked to professional and technical services, high tech manufacturing and information workers.

Because mining degrades the natural environment, mining-dependent areas become less attractive places to live, work, and do business, as indicated by the comparison of places with and without mining in Section II.2 above. Specifically, mining will directly diminish and/or displace "amenity supported" industries like

[37] Headwater Economics. Economic Profile System: Socioeconomic Indicators Gila County, AZ. Tab 15. 7.7.2023
[38] Census. Globe city, Arizona. Quick Facts. 7.1.2022. Accessed 7.7.2023. https://www.census.gov/quickfacts/fact/table/globecityarizona/RTN131217
[39] Census. Payson town, Arizona. Quick Facts. 7.1.2022. Accessed 7.7.2023. https://www.census.gov/quickfacts/paysontownarizona
[40] Rim Country Regional Chamber of Commerce. This is Rim Country. https://www.rimcountrychamber.com/visit-rim-country Accessed 8.1.2023.

outdoor recreation, and such disruption will ripple through connected industries. For example, future loss of recreation opportunities could deter some people from moving or staying in the Pima County area, which in turn could affect the housing market.

We can get some idea about the cumulative effects of mining on an economy by looking at a national level, where many smaller effects are subsumed in macro-indicators. For example, the country of Chile has based much of its economy on copper mining and processing to the detriment of the environment and potential diversified industries that depend on a healthy environment.[41] A study by Mardones found that nearly all the economic benefits that Chile has received from copper mining, measured as contributions to gross domestic product (GDP), were cancelled out by "depreciation of natural capital, the environmental degradation due to the emissions of atmospheric pollutants and the exploration expenses of copper mining during the period between the years 1995 and 2015."[42] Mardones calculated that during this period, when Chile led the world in copper production and copper appeared to represent as much as 44% of GDP, more than 98% of that economic value was offset by environmental degradation and costs associated with the mining, meaning that only 2% of the value generated by mining benefited people in the country.

Arizona, in 2022, produced more copper than any other U.S. state, "70% of domestic output."[43] We might expect that if a Mardones-type study were to be completed in the future for Pima County, it would find similar results: Hudbay, a Canadian company, would likely export its profits, and Pima County would be left with the environmental degradation and human health impacts. Eventually, the mine would exhaust its copper reserves and from that point on contribute nothing to the economy, leaving behind a degraded environment with tailings storage facilities and open pit mines that will continue to exact an economic cost in perpetuity. From Pima County's perspective, such perpetual costs must be factored into any cost-benefit analysis. Is the 20-year gain from the mine's jobs and taxes worth the perpetual environmental and socioeconomic degradation?

III. Copper's role in supporting the U.S. transition to green energy

Recently, as the world attempts to transition away from fossil fuels to renewable energy, the U.S. and other nations have been making plans to ensure supplies of

[41] According to the World Copper Factbook, 2020, Chile is the world leader in copper production and third in smelter production. International Copper Study Group. The World Copper Factbook 2020. 2020.
[42] Mardones, C., del Rio, R. Correction of Chilean GDP for natural capital depreciation and environmental degradation caused by copper mining. *Resources Policy*. Volume 60. 2019.
[43] USGS. MCS 2023. Copper. Accessed 10.11.2023. https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-copper.pdf

essential raw materials. President Biden recently asked the U.S. Geological Survey (USGS) to update the list of *critical minerals* on a more frequent basis, based on the most up-to-date science as mandated in the Energy Act of 2020. There are many reasons for the update, but near the top of the list is concern that the U.S. currently relies on supplies of critical minerals from nations with whom we do not have reliable trade relations. This includes countries like China and Russia that have historically been large producers of critical minerals and/or control the overland routes from countries that do.[44]

> "USGS data collection and analysis scans the horizon for emerging issues in crucial supply chains, and every three years identifies the nation's current vulnerabilities to potential disruptions…The Energy Act of 2020 defines a "critical mineral" as a non-fuel mineral or mineral material essential to the economic or national security of the U.S. and which has a supply chain vulnerable to disruption. Critical minerals are also characterized as serving an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economy or national security."[45]

Copper is not on the U.S. Geological Survey (USGS) list of critical minerals[46] because global supplies are abundant, with large quantities produced by the U.S. and other nations with whom the U.S. has been historically on good terms (e.g., countries with whom the U.S. has Free Trade). As the director of the USGS, Director David Applegate, stated:

> "The U.S. has significant domestic copper production and a diversity of foreign supply sources. The USGS estimates that the United States mined 1.3 million tons of recoverable copper in 2022. Copper was mined in seven different states (led by Arizona) and the United States has multiple domestic options for downstream smelting and refining to copper metal. The United States has 25 operating copper mines, 2 smelters, 2 electrolytic refineries, and 14 electrowinning facilities. In addition, the observation that more than half of the global supply of refined copper is produced in China, Russia, North Korea, and Iran, while factually correct, is not directly relevant to the copper supply of the United States. Imports of refined copper to the United States are not dependent on any of the countries cited. American imports of

[44] Shondhart, S. U.S. Looks to Mongolia, Edged Between China and Russia, for Critical Minerals. Scientific American. 7.31.2023. Accessed on 8.30.2023. https://www.scientificamerican.com/article/u-s-looks-to-mongolia-wedged-between-china-and-russia-for-critical-minerals/

[45] USGS. U.S. Geological Survey Releases 2022 List of Critical Minerals. 2.22.2022. Accessed 6.13.2023. https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals

[46] Recently the Department of Energy (DOE) put Copper on their "critical minerals for energy" list. However, the DOE does not control the "Critical Minerals" list which is created by the USGS and is the list that the I.R.A. Act, for example, bases their tax rules off of. Secondarily, even though the DOE put copper on their "critical minerals for energy list", their own tables suggest that it is not "critical" and instead falls into the confusing "near critical in the medium term" category. US DOE. What Are Critical Materials and Critical Minerals? Accessed 8.7.2023. https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals

refined copper come predominantly from Chile, Canada, and Mexico, reliable trade partners with whom the U.S. has free trade agreements.

Finally, the United States supplied about a third of its domestic copper consumption requirements from recycling in 2022, a good example of the potential for secondary production to mitigate supply chain risks."[47]

The recent push by Arizona Senator Sinema and other national politicians to put copper on the USGS's critical minerals list is based in part on the misconception that the U.S. may fall short of copper as global investment in green energy ramps up. The reality is, as the USGS stated, that the U.S. produces substantial amounts of copper, we have robust secondary supplies (recycling), and we import copper from many countries with whom we have free trade agreements.

When analysts evaluate whether there will be a global copper supply shortage over the next five to ten years, they conclude that copper suppliers will be able to cover the rather large increase in demand with available mines and available technology.[48] It follows that U.S. national security does not depend on developing the Copper World project.

There has been some confusion recently because, following the USGS publication of its list of "critical minerals," which excluded copper,[49] the Department of Energy (DOE) listed copper as a critical *material* in its 2023 Critical Materials Assessment.[50] It's important to note that, although this assessment listed copper as a critical material, this categorization is apparently contradicted by details in assessment, which did *not* designate copper as critical in either in the near term (2020-2025) or medium term (2020-2035). The DOE did not project status beyond 2035, possibly because the effects of factors like material substitution (e.g., substituting aluminum for copper in underground cables[51]) are too uncertain to accurately project out that far.

It is unclear whether inclusion of copper in the DOE's 2023 Critical Materials Assessment would allow copper-mining projects to qualify for Inflation Reduction

[47] Applegate, D. Dear Senator Sinema. USGS. 4.13.2023.
[48] Crooks, S. et al. Bridging the Copper Supply gap. McKinsey & Company. 2.17.2023. Accessed 6.28.2023. https://www.mckinsey.com/industries/metals-and-mining/our-insights/bridging-the-copper-supply-gap#/
[49] Recently the Department of Energy (DOE) put Copper on their "critical minerals for energy" list. However, the DOE does not control the "Critical Minerals" list which is created by the USGS and is the list that the I.R.A. Act, for example, bases their tax rules off of. Secondarily, even though the DOE put copper on their "critical minerals for energy list", their own tables suggest that it is not "critical" and instead falls into the confusing "near critical in the medium term" category. US DOE. What Are Critical Materials and Critical Minerals? Accessed 8.7.2023. https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals
[50] US DOE. What Are Critical Materials and Critical Minerals? Accessed 8.7.2023. https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals
[51] International Energy Agency (IEA). 2021. The Role of Critical World Energy Outlook Special Report Minerals in Clean Energy Transitions. https://iea.blob.core.windows.net/assets/ffd2a83b-8c30-4e9d-980a-52b6d9a86fdc/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf. Accessed 12.26.2023.

Act tax incentives.[52] S&P Global believes strongly that copper does not qualify for Inflation Reduction Act tax incentives, and that report references the DOE's critical materials list. S&P Global goes on to point out that "Products manufactured in these countries (Foreign Entities of Concern) are potentially disqualified from the IRA's tax credits."[53] If this is the case, then this would disallow copper concentrate from being processed by refineries in China into finished copper (cathodes). Although Hudbay hints that their project may get "funding/government incentives for critical materials processing,"[54] it is unclear where that funding would come from. According to Hudbay's revised 2023 PFS, for at least the mine's first four years, pure copper will not be produced on-site, and their impure copper concentrate will be exported onto the world market.[55]

> "100% of the copper produced at Copper World during the first 4 years will be in the form of concentrate and sold externally. Global copper concentrate fundamentals are expected to be strong in the medium/longer term."[56]

Hudbay's copper concentrate that is sold into the global market likely will not qualify as made in the U.S. copper, unless it is processed by countries with Free Trade Agreements with the U.S. and will not qualify for tax advantages as discussed above. As is noted later in this report, there is no refining capacity in the U.S. for Hudbay's copper concentrate and China is the dominant world leader in copper refining.

According to the 2023 PFS, at no time will Hudbay refine 100% of its Copper World ore to 99-percent pure copper cathodes in the U.S. As cited above, during the mine's first four years of operation all copper concentrate will be shipped overseas for refining. Beginning in year five, Hudbay plans to construct an SXEW plant to refine 58% of its copper concentrate to finished copper cathodes, but Hudbay would still sell 42% of the concentrate in the global market for the next 16 years until the projected end of the mine's life.[57]

This export option was initially discussed in a 2022 Hudbay Third Quarter Earnings Call[58] by André Lauzon, Hudbay's chief operating officer. Lauzon confirmed the possibility of relying on smelting as an alternative to producing copper cathodes on-

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[52] S&P Global. Inflation Reduction Act: Impact on North America metals and minerals market. S&P Global. August 2023. Page 10.
[53] S&P Global. Inflation Reduction Act: Impact on North America metals and minerals market. S&P Global. August 2023. Page 27.
[54] Hudbay. Copper World Phase I Pre-Feasibility Study Presentation. Page 12. 9.8.2023. Accessed 9.12.2023. https://s23.q4cdn.com/405985100/files/doc_presentations/2023/09/08/Copper-World-PFS-Presentation_Sept2023_FINAL.pdf
[55] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 1-15.
[56] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 1-15.
[57] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 22-4.
[58] Seeking Alpha. Hudbay Minerals Inc. (HBM) Q3 2022 Earnings Call Transcript. 11.3.2022. https://seekingalpha.com/article/4552569-hudbay-minerals-inc-hbm-q3-2022-earnings-call-transcript?utm_campaign=%7Clogin_now_link&utm_medium=email&utm_source=seeking_alpha

site. Since there are no operating smelters in the U.S. with excess capacity,[59] the concentrate would have to be shipped to processing facilities outside of the U.S. This indicates that selling the concentrate into the global market has always been Hudbay's plan.

The most likely destination, based on refining capacities, is that the concentrate would go to Asia, and specifically China.[60] Of the top 20 largest copper refineries in the world, China is home to 10 of them. The U.S., by comparison, has only one refinery in the top 20 that represents a little less than 5% of the top 20's capacity.[61] China is so dominant in copper smelter refinery production, sitting at number one in the world, that in 2019 they had about 6 times as much capacity as Japan, the country in second place.[62] The possibility that the copper produced by the proposed mine would be sent to a foreign country runs counter to Hudbay's marketing for the Copper World/Rosemont Mine Complex, which claims that their copper will be "Made in America."[63]

IV. Analysis of economic benefits from the Copper World project

Any attempt to forecast the ultimate economic and social effects of the mine faces difficulties. One is uncertainty about Hudbay's ultimate plans, which have changed significantly in just the past year. Hudbay released one detailed plan in its 2022 Preliminary Economic Analysis (PEA) and then replaced it with a fundamentally different plan in its 2023 Phase I Pre-Feasibility Study (PFS).[64]

These plan changes introduce uncertainty about what Hudbay will ultimately do and whether the current plan will be followed or whether plans will change again. For example, fluctuations in market demand and the price of copper will likely change potential production levels and profit margins and might, therefore, change the mine operating plan.

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[59] According to the ICGS Directory of Copper Mines and Plants, there are five operating 'traditional' copper refineries in the U.S. and they are all at capacity. International Copper Study Group. Directory of Copper Mines and Plants Up to 2024. 3.10.2021. Page 222.
[60] International Copper Study Group. Directory of Copper Mines and Plants Up to 2024. 3.10.2021. Page 26.
[61] China has 58% of capacity of the top 20 smelters in the world. International Copper Study Group. Directory of Copper Mines and Plants Up to 2024. 3.10.2021. Page 40.
[62] International Copper Study Group. The World Copper Factbook 2020.
[63] Hudbay. Hudbay Announces Robust Preliminary Economic Assessment for the Copper World Complex. 6.8.2022. Accessed 9.7.2023. https://hudbayminerals.com/investors/press-releases/press-release-details/2022/Hudbay-Announces-Robust-Preliminary-Economic-Assessment-for-the-Copper-World-Complex/default.aspx
[64] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Cautionary Note Regarding Forward-Looking Information. Copper World Project. 7.1.2023. https://s23.q4cdn.com/405985100/files/doc_downloads/2023/09/20230907-2023-CopperWorld-PFS_FINAL.pdf

Remember from Figure 3, in section II.1 above, that past employment in copper mining in Arizona very closely tracked production. If the price of copper goes down far enough, then the mines will begin to idle workers or shut down altogether. Hudbay itself warns in the PFS that "The risks, uncertainties, contingencies and other factors that may cause actual results to differ materially from those expressed or implied by the forward-looking information [in the PFS] may include, but are not limited to…" This section then goes on to list 17 factors that include future commodity prices, changes in government policy, and litigation.[65]

Another major challenge to forecasting the mine's effects is that, because Hudbay now plans to carry out Phase I mining activities only on private and possibly state land, it does not have to be analyzed under the National Environmental Policy Act (NEPA),[66] as it would if the mining were to take place on federal land which requires federal oversight. This means that, by avoiding a "federal nexus," the mine plan will not undergo the rigorous public economic, social, and environmental analysis required by NEPA. Therefore, the public does not have key pieces of information, for example, the complete shipping route for the copper concentrate, nor is there in-depth analysis of effects on the environment, socioeconomics, and human health.

Such lack of essential public information is typical of mining projects. For example, Meintsma studied sulfide copper-ore mining in the Boundary Waters Canoe Wilderness Area in Minnesota[67] and concluded that the current structure of federal environmental law does not effectively allow a transparent weighing of public costs, benefits, and risks when land use decisions are being made.[68] He recommended that:

> "Finally, information asymmetries should be reduced, while strict liability standards must be improved upon to ensure adequate compensation for incurred costs caused by environmental degradation and displaced industries. Implementation of these policy tools will combine to act as safeguards, ensuring prioritization of environmental protection interests in the event that sulfide-ore mining operations commence in the state of Minnesota."[69]

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[65] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023.
[66] EPA. National Environmental Policy Act. Accessed 10.10.2023. https://www.epa.gov/nepa
[67] Meintsma, S. Prioritizing Environmental Protection: Regulating Sulfide-Ore Mining in the Boundary Waters Canoe Area Wilderness of Northeastern Minnesota. *Journal of Public and Environmental Affairs*. April 2020.
[68] The White House. Readout of the White House's First Stakeholder Convening on Mining Reform. May 11, 2022. Accessed on 6.27.2023. https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/11/readout-of-the-white-houses-first-stakeholder-convening-on-mining-reform/
[69] Meintsma, S. Prioritizing Environmental Protection: Regulating Sulfide-Ore Mining in the Boundary Waters Canoe Area Wilderness of Northeastern Minnesota. Journal of Public and Environmental Affairs. April 2020.

This statement seems particularly applicable to Copper World because there is almost no public information outside of Hudbay's PEA and PFS. Our report therefore attempts to fill some of the gaps left by the lack of NEPA analysis and the skimpiness of details in the 2023 PFS. In this section we put the number of jobs Hudbay says it will create into the context of the greater Tucson area's economy, and we evaluate how future changes in the price of copper may affect the mine's economic viability.

1. Overview of Hudbay's plans

The changes from Hudbay's 2022 plan to the 2023 plan appear to have been driven by at least two desires: cutting the initial capital cost estimate from $1.9 to $1.3 billion[70] and shifting the initial work from federal land on the east side of the mountains to private and possibly state land on the west side.

These desires have changed where, when, and how copper ore will be mined and processed. In 2022 Hudbay was planning to start mining on the east side of the mountains, at what it now calls the Rosemont Pit, where there is much more ore than in the relatively shallow deposits on the west side. That plan involved using a large amount of national forest land on the east side to place tailings piles. Because a court decision in 2023 prohibited Hudbay from placing most of its tailing on the national forest lands,[71] the plan has changed. In the PFS's 2023 plan, Hudbay now proposes to start on the west side, using private land, before moving to only private land on the west side to mine the Rosemont Pit.

As of 2023, Hudbay plans four open pit mines (three on the east side and the Rosemont Pit on the west),[72] processing facilities (milling initially and then potentially leaching, solvent extraction, and electrowinning after year four), waste rock storage area, and multiple tailings storage facilities.

Despite the new exclusive focus on private land, Hudbay is still hoping for federal permits to build a larger and, so far, undisclosed operation that would constitute Phase II. In September 2023 press release Hudbay wrote, "This confirms significant upside at Copper World with an intended Phase II expansion of mining activities onto federal land to further enhance the project economics and extend the mine life well beyond 20 years."[73] Talking about the constraint of limited space for placing mine tailings, particularly in the east side, the PFS says:

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[70] Hudbay. Hudbay De-risks Copper World Phase I with Enhanced Pre-Feasibility Study. https://hudbayminerals.com/investors/press-releases/press-release-details/2023/Hudbay-De-risks-Copper-World-Phase-I-with-Enhanced-Pre-Feasibility-Study/default.aspx. Accessed 1.1.2024.
[71] Grzincic, B. 9th Circuit rules against Rosemont Copper mine. Reuters. 5.13.2022. Accessed 6.9.2023. https://www.reuters.com/legal/government/9th-circuit-rules-against-rosemont-copper-mine-2022-05-13/
[72] Peach-Elgin, West, Broadtop Butte, and East. Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-11
[73] Hudbay. Hudbay De-risks Copper World Phase I with Enhanced Pre-Feasibility Study. 9.8.2023. https://hudbayminerals.com/investors/press-releases/press-release-details/2023/Hudbay-De-risks-Copper-World-Phase-I-with-Enhanced-Pre-Feasibility-Study/default.aspx. Accessed 1.1.2024.

> "These important constraints result in a sub-optimum mining sequence from a strict economic standpoint but allow the mine to operate in a sustainable manner for 20 years until federal permits are in place. Securing these permits earlier would unlock significant benefits to the Project by removing these important constraints on the mining schedule allowing more tons and/or better grade to enter the mine plan earlier than currently planned."[74]

The Phase I PFS included the following changes from the 2022 PEA:

- There will now be 430 direct jobs instead of 500, although both plans project that 3,000 secondary jobs will be created as a result of the mine's economic activity.[75]
- Instead of refining the ore to pure copper cathodes from the beginning of production, as envisioned in the 2022 PEA, Hudbay now plans to export copper concentrate into the world market for at least the first four years, and then may invest in a concentrate leaching facility that would produce copper cathodes on-site.[76] (Copper cathodes are 99-percent pure copper plates that are sold to industry.) However, even if they build a SXEW plant, they will still export more than 40% of their concentrate onto the international market.
- Hudbay's new Phase I, in which it will mine the four pits described above, will last for 20 years, followed perhaps by a completely undisclosed Phase II on public land. The 2022 PEA planned for a 44-year project just on the east side.[77]
- The break-even price, i.e., the price below which the mine loses money, for pure copper was changed from $3.45 to $3.75.[78]
- Hudbay has abandoned ROM leaching (Run Of Mine, also called dump leaching or heap leaching) and now plans to sell its excess sulfuric acid "on the local market."[79]

[74] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-11.
[75] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-18.
[76] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-2 and page 1-15.
[77] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-1.
[78] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-8.
[79] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 13-15.

- Hudbay plans to move some of its waste rock twice to dispose of it in the pits that are mined in the initial 5 years.[80] This results in a "sub-optimum mining sequence from a strict economic standpoint."[81]

2. Analysis of copper price

To evaluate how the Copper World project will affect the greater Tucson economy, it is essential to understand how world copper prices will determine how large the mine's production will be over time, and even whether the mine is economically viable. In turn, the level of production will determine the mine's ability to provide stable jobs, taxes, and other economic benefits.

A key concept is the break-even price, which is the price at which the company can sell its copper and make a profit given its costs. Of course, the richer the ore and the more efficient the production, the lower the break-even price.

If the concentration of copper per ton in a given deposit is so low that production costs exceed the break-even price, that ore will not be profitable to pursue. Of course, at a given market price and production efficiency, it may pay to process areas with richer ore, while not mining areas with lower copper concentrations. At a particular break-even price there may well remain many millions of dollars of lower concentration ore not worth mining.

The modelling in the PFS assumes a break-even price of $3.75 per ton,[82] up from $3.45 in the 2022 Preliminary Economic Analysis. A key question for potential investors in the mine is whether this price is going to be consistently achievable.

Using the Consumer Price Index[83] to adjust the price of copper to constant 2022 dollars, the price has been below the $3.75 threshold about 52% of the time since 2010.[84] During this time, the price of copper has been relatively volatile (Figure 4 below), and it is clear that maintaining a $3.75 per pound market price over the 20-year time frame that Hudbay proposes to operate the mine is unlikely.

Since 2010, the peak adjusted copper price was $5.91 per pound in February of 2011 and the low was $1.06 per pound in September of 2001. Compared to the peak, copper lost about 82% of its value in the decade from 2010 to 2001 and has not approached the historical 2011 high since. The average price of copper over this time period was $2.91/lb. which is $0.84 *below* Hudbay's stated break-even price.[85] The

[80] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-11.
[81] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-11.
[82] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-8.
[83] St. Louis FED. Consumer Price Index for All Urban Consumers: All Items in U.S. City Average. https://fred.stlouisfed.org/series/CPIAUCSL
[84] FRED. Global price of copper. Accessed 10.11.2023. https://fred.stlouisfed.org/series/PCOPPUSDM#0
[85] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-8.

point is that there is nothing in the last thirty plus years of copper prices that would suggest that the price of copper will stay at or above $3.75/lb. for 20 years. In fact, Hudbay itself says that, if copper prices fall below $3.50 per pound, its business will be "squeezed".[86]

Copper, like most commodities sold on international markets, suffers through irregular but repeated cycles (see Figure 3 above and Figure 4 below). In general, when international demand for copper rises, global prices move upward, motivating existing mines to increase production. Expanding international demand also leads to building new mines and processing facilities.

We can see the relationship between employment and production in Figure 3, above, where mining employment and production track each other. If we analyze employment in metal mining in Arizona compared against the price of copper over the same period, we see a very strong correlation between the two. This suggests that mining employment tracks the price of copper in Arizona.[87] In other words, when the price of copper is high, the mines hire more miners and ramp up production. Conversely, when the price of copper is low, Arizona mines lay miners off.

At some point, the increase in supply exceeds demand, and the over-supply begins to drive copper prices down. As a result, production from some sources becomes unprofitable at the new lower prices (when prices drop below a mine's break-even price) and international copper production is scaled back. Both Figure 3 and Figure 4 illustrate this volatility in production, mine employment, and the price of copper. Note that in Figure 3 employment and production move rather dramatically, and there is no monotonic increase or even steady-state period where employment and production are stable. This historical pattern strongly contrasts with Hudbay's assertions that 3,430 people will be continuously employed as a result of the mine for 20 years.

Eventually, mines always deplete their economically viable ore deposits and shut down. Although the Copper World project may hope for high and stable prices for their minerals for the life of the mine, the reality is that production will follow the price of copper, and the price of copper is, has been, and is likely to continue to be volatile.

[86] Rajagopal, D. and Burton, M. Focus: Smaller Miners' hunger for cash grows as copper prices fall, sparking M&A bets. Reuters. 7.24.2023. Accessed 8.7.2023. https://www.reuters.com/markets/commodities/smaller-miners-hunger-cash-grows-copper-prices-fall-sparking-ma-bets-2023-07-24/

[87] Internal calculation looking at data from Headwater Economics' Arizona Mining, Including Oil and Gas, statistics from their Economic Profile System. Comparing employment and the price of copper from 2001-2022.

Figure 4.

Source: Federal Reserve Bank of St. Louis. Global Price of Copper and CPI. 5.12.2023. https://fred.stlouisfed.org/series/PCOPPUSDM#0

Figure 4 shows the "real" price of copper at constant 2022 dollars since 1990 as well as the $3.75 per pound break-even threshold that Hudbay is using.

3. Analysis of Hudbay's employment projections

The following analysis of job generation and salary is based on Hudbay's mining plan as proposed in the PFS, all of which assumes that copper prices remain at or above $3.75. Although miners may be attracted to jobs from other areas of Arizona or from other states, for the purposes of this analysis we have assume that all miners hired by the mine will be hired from Pima County residents. We also assume that the direct mining jobs will get paid the average wage for a miner in Pima County, which was about $99,000 per year in 2022.[88] The third assumption is that the other "3,000 indirect jobs," will go to residents of Pima County and that they will be paid the average wage for Pima County in 2022, which was $59,624[89] (Table 1).

[88] Headwater Economics. A Profile of Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 10.
[89] Headwater Economics. A Profile of Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 10.

a. Direct jobs

The PFS projects that the mine will employ 430 miners directly in permanent operating jobs, 750 temporary construction jobs, and 3,000 permanent secondary jobs.[90] In our analysis we will just look at permanent jobs. We will assume that 430 miners will be permanently employed even though, given the lack of information released by Hudbay, there is no way of independently determining the annual rate of ore extraction and processing and therefore the number of miners who will be employed.

430 jobs would increase the current 3,300 mining jobs in Pima County by 13%. Since mining represented about 0.6% of all jobs in Pima County in 2021, the 430 new mining jobs would represent an increase in total county employment of only 0.08%. In terms of the county's job growth, these new mining jobs would represent a relatively modest increase of some 4% of the 11,530 jobs that were created between 2020 and 2021.[91]

In 2021, Pima County miners earned on average about $99,000 per year, about 66% more than the average wage,[92] which for 430 miners translates into about $43 million in direct wages per year. $43 million is about 0.07% of total personal income in Pima County.

Income from Hudbay's 430 direct mining jobs would equal only 0.07% of all Pima County income and summing Hudbay's projected 3,450 direct and secondary jobs would equal 0.37% (see Table 5.).

b. Secondary (indirect) jobs

Hudbay projects that the 430 direct mining jobs will create an additional 3,000 secondary jobs, which exist to provide goods and services needed by the mine itself and the workers with direct jobs.[93] At an average wage for Pima County of $59,624, this translates into $179 million for 3,000 miners. This represents an increase in total personal income of 0.3%. For the moment, we will assume Hudbay's figures are correct, but in the analysis below (Section IV.3d) we discuss reasons we believe that the number of indirect jobs will be less than 3,000.

We do not know how these indirect jobs will be distributed among industries. A detailed analysis using an input-output model (like IMPLAN) is normally used to

[90] Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-18.
[91] Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. Tab 6. 6.7.2023.
[92] We do not know what the pay per job will be for the direct miners, so we are using the average pay per mining job in Pima County. Until more detailed information is available, we use this pay per job as a stand in. Headwater Economics. Economic Profile System: Socioeconomic Indicators Pima County, AZ. Tab 10. 6.7.2023.
[93] A 'multiplier' is the recirculation of the spending of the direct workers' pay as well as the spending from the mine to procure supplies for the mine. Taken together, this spending is called 'secondary' spending. The ratio of the direct jobs to the jobs that are created by the secondary spending is the multiplier.

evaluate what sorts of jobs would be generated by an operation like a mine, but such an analysis has not been provided in Hudbay's technical documents.

c. Direct plus secondary jobs

Taken together, the 3,430 direct and secondary jobs projected by Hudbay would represent 0.64% of Pima County's total employment and would contribute about 0.37% of total personal income in Pima County. See Table 2. The reason they would constitute a higher percentage of Pima County jobs (0.64%) than of Pima County personal income (0.37%), is that total personal income includes non-labor income, which in Pima County accounts for almost half of all personal income.

Table 1.

	# of Jobs	Pay per Job	Total
Hudbay Direct	430	$99,143	$42,631,490
Hudbay Secondary	3,000	$59,624	$178,872,000
Hudbay Total Mining	3,430	$64,578	$221,503,490
Pima County	534,770	$59,624	$31,885,126,480

Source: Headwater Economics. A Profile of Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023.

Table 2.

	% of Jobs	% of Pay
Hudbay Total % of Pima	0.64%	0.37%
Hudbay Direct % of Pima	0.08%	0.07%

Source: Internal Calculations.

Table 1. shows the direct, secondary, and total mining jobs projected by Hudbay as well as the number of jobs in Pima County. The pay per job for the direct, secondary, total mining jobs, and Pima County comes directly from the Headwater Economics data.

Table 2. shows the relative number of the Copper World Complex mining jobs with respect to Pima County. The total jobs (3,430 from table 1) are compared against the total jobs in Pima County (534,770 from table 1). The same methodology is used in direct jobs compared to total. The percentage of pay is the percentage of total pay from all the mine workers compared against total personal income, which is almost twice what total labor income is in Pima County. The same methodology is used in direct pay compared to total personal income.

d. Why the mine would likely create fewer than 3,000 secondary jobs

When Hudbay asserts that the mine would create 3,000 secondary jobs, this implies a multiplier of nearly 7 (6.98 x 430 = 3,000). Evidence suggests that this multiplier is

much higher than for mines generally and that in reality fewer than 3,000 secondary jobs would be created.

For example, researchers at Northern Illinois University calculated a multiplier of 2.41 for sand and gravel mining in LaSalle County, Illinois.[94] In another study, Bivens determined a multiplier of 4 to 5 for mining and/or metal mining in the entire U.S.[95] Because multipliers calculated for a large area like a nation are typically larger than for smaller areas like counties, Bivens' findings also suggest that a multiplier of 7 is unrealistically high.[96]

Fleming found that multipliers for mining communities in Australia varied with the "secondary" industry involved. Some services like "accommodations and food services" had multipliers of 1.5, while secondary industries, like "arts and recreation services" had multipliers smaller than one.[97] A multiplier smaller than one means that a new mine caused that industry to shrink.

There is another example of economic input output modeling and the multipliers associated with it that is much more analogous to Pima County and the potential for the Copper World project. The proposed Resolution Copper mine in Superior AZ. is currently in the NEPA process. As part of that process, a Final Environmental Impact Statement (FEIS) is required, and in that FEIS, a socioeconomic section is mandated.

BBC Consulting produced a report which was used as the basis for the socioeconomic section in the Resolution FEIS that was rescinded.[98] In that report, BBC modeled the economic impact of the proposed Resolution Copper mine on the town of Superior, Arizona the *local* level, which was defined as the Copper Triangle, and the *county* level, including Pinal, Gila, Graham, Maricopa, and Pima Counties. The multiplier that BBC consulting found for the "regional effects," which included all of the counties previously mentioned, was 1.88 for labor income and 2.44 for employment, several times smaller than the multipliers claimed by Hudbay for the Copper World project.

Unsurprisingly, the smallest effects were in the town of Superior, followed by the Copper Triangle, and the largest effects were in the counties, particularly Maricopa

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[94] Harger, B. Economic Impact Analysis: The LaSalle County Mining Industry. March 2015. https://www.iaap-aggregates.org/uploads/1/1/0/0/110027599/economic_impact_analysis_of_the_lasalle_county_mining_industry.pdf

[95]For mining it was 4.5 and for metal mining it was 4.7. Bivens, J. Updated employment multipliers for the U.S. economy. 1.23.2019. https://www.epi.org/publication/updated-employment-multipliers-for-the-u-s-economy/

[96] A county multiplier will only reflect sales within the county, which is unlikely to provide everything that a mine needs to buy, while the national multiplier will reflect all sales within the country.

[97] Flaming, D., and Measham, T. Local job multipliers of Mining. Resources Policy. 2014.

[98] BBC Research and Consulting. Socioeconomic Effects Technical Report- 202 Update. Resolution Copper Mine Environmental Impact Statement. September 14, 2020. https://www.resolutionmineeis.us/sites/default/files/references/bbc-research-socioeconomic-effects-update-2020.pdf

County, which includes Phoenix. According to BBC, Maricopa County "could receive up to 81% of the "multiplier" effects."[99]

Superior, the town directly adjacent to the proposed mine, was projected to have a jobs multiplier of 1.21 for employment and 1.06 for labor income. In other words, for every job directly supplied by the proposed Resolution mine, Superior would receive .21 secondary jobs, and for every dollar in labor income directly generated, Superior would receive 6 secondary *cents*.

Pima County was included in this analysis and received a very small amount of the secondary jobs and income. This is important because it shows that Pima County is unlikely to surpass other counties in Arizona and/or the country when it comes to supplying the needs of copper mines.

Because the multiplier for the entire economy in an area, e.g., Pima County, is a function of the individual multipliers for the individual industries, it is possible that small or negative multipliers in some industries could be more than offset by large positive multipliers in others. This would mean that countywide more secondary jobs would be created than lost.

The converse could also be true. Within a county, positive multipliers for industries like accommodation and food services could be more than offset by negative multipliers in industries like arts and recreation services, notably outdoor recreation in the case of Pima County, indicating a net loss of secondary jobs. The reasons that we believe this to be the case for Pima County will be discussed in detail in Section V. of this report.

Even if we were to take the best scenario for Hudbay, which is that the mine would create 430 permanent mining jobs and an additional 3,000 secondary jobs, this represents far less than a 1% increase in the more than half a million Pima County jobs.

4. Analysis of Hudbay's tax payments

Hudbay asserts that:

> "Over the anticipated 20-year life of the operation, the company expects to contribute more than $856 million in U.S. taxes, including approximately $168 million in taxes to the state of Arizona... The Project is estimated to generate $247 million in property taxes over the 20 years of operation."[100]

[99] BBC Research and Consulting. Socioeconomic Effects Technical Report- 202 Update. Resolution Copper Mine Environmental Impact Statement. September 14, 2020. Section I, Page 9. https://www.resolutionmineeis.us/sites/default/files/references/bbc-research-socioeconomic-effects-update-2020.pdf

[100] [100] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 1-18.

Local property taxes

The $12.35 million per year in property taxes would primarily benefit Pima County. Hudbay's projected contribution would be almost 0.9% of Pima County's total intake of property taxes, which were "more than $1.44 billion" in fiscal year 2023/2024.[101]

Local property taxes represent 31% of the total tax dollars received by Pima County[102] and help support a wide variety of services including libraries, operations and maintenance, public safety, community services, health, and parks and recreation, with the remainder contributed by sales and other taxes.[103]

K-12 education is the single largest expenditure of property taxes in the state, constituting about half of all expenditures.[104] Therefore, about half of all property taxes paid to Pima County would go toward K-12 education. Arizona uses an equalization system to share county property tax income between richer and poorer counties in the state to ensure that schools in districts with lower property values receive adequate funding.[105] This means that about half of the funding that Hudbay may pay towards property taxes will be equalized across the state and will not necessarily directly support Pima County.

Income taxes. Hudbay projects that it will pay $168 million in taxes to the state of Arizona during the lifetime of the mine. This would be $8.4 million per year over the 20-year Phase I of the mine, which would represent 0.03% of Arizona's 2022 tax revenues of $27.8 billion.[106] Although $8.4 million is a large annual number, it is a very small value when compared to the state's total 2022 tax collections.

In federal income taxes, Hudbay expects to pay about $43 million per year over the life of the mine, some 0.009% of the $4.9 trillion total federal income taxes collected 2022.[107]

In summary, Hudbay's income tax payments to the state and federal governments would be trivial compared to the total taxes these governments would receive. Hudbay's property tax contribution to Pima County would make up a larger

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[101] Pima County. Sources of Funds & Uses of Tax Dollars. Accessed 9.1.2023. https://www.pima.gov/629/Sources-of-Funds-Uses-of-Tax-Dollars
[102] Pima County. Sources of Funds & Uses of Tax Dollars. Accessed 9.1.2023. https://www.pima.gov/629/Sources-of-Funds-Uses-of-Tax-Dollars
[103] Pima County. Sources of Funds & Uses of Tax Dollars. Accessed 9.1.2023. https://www.pima.gov/629/Sources-of-Funds-Uses-of-Tax-Dollars
[104] Arizona Department of Revenue. Overview of the Arizona Property Tax System. 2023. https://azdor.gov/sites/default/files/2023-03/PROPERTY_OverviewAZPTSystem.pdf
[105] Arizona Department of Revenue. Overview of the Arizona Property Tax System. 2023. Page 40. https://azdor.gov/sites/default/files/2023-03/PROPERTY_OverviewAZPTSystem.pdf
[106] Arizona Department of Revenue. Annual Report: FY 2022. November 2022. Page 10.https://azdor.gov/sites/default/files/2023-03/REPORTS_ANNUAL_2022_ASSETS_fy22_annual_report.pdf
[107] Congressional Budget Office. Monthly Budget Review: Summary for Fiscal Year 2022. Accessed on 6.16.2023. https://www.cbo.gov/publication/58592/html#:~:text=larger%20than%20projected.-,Total%20Receipts%3A%20Up%20by%2021%20Percent%20in%20Fiscal%20Year%202022,the%20receipts%20recorded%20in%202021.

proportion of the county's budget but would still be well under 1%, particularly after taking into account education equalization.

V. Economic values at risk from the Copper World project

Hudbay's 2023 PFS projected possible direct *benefits* to Pima County in the form of new jobs and taxes, which we analyzed in Sections IV.3 and IV.4 above. However, the PFS did not examine potential *costs*. Concerns about these public costs have led the Pima County Board of Supervisors and City of Tucson, among other entities, to oppose the project.[108] In this section we interpret past economic studies that have characterized typical *costs* of mining so that citizens and decision-makers can better understand how the proposed mine would affect in-migration, property values, service industries in general, outdoor recreation, and the character of Pima County as a place to live, recreate, work, and do business.

To get at whether the proposed mine will damage the greater Tucson area economy more than it will boost economic vitality, we can divide the mine's effects into two categories. First are what might be considered direct effects of the mining activity, for example converting the natural landscape to an industrial zone disrupts service-related industries like outdoor recreation and tourism.

The second category is the secondary effects caused by mine activity that makes the area a less attractive place to live. The most important of these would be a significant decrease in in-migration or an increase in out-migration.

Because Hudbay's plan, outlined in its 2023 PFS, has so little information on basic things like the potential toxicity of the tailings or the complete route that truck traffic will follow to market, it is difficult to assess how much direct or indirect harm the mine will do to the various economic sectors. Likewise, at the moment, there is no NEPA analysis planned, so we are lacking detailed analysis and modelling of the magnitude of such damaging effects on local industries. However, even absent this information, the below analysis shows there will be significant negative effects on many interrelated sectors of the economy. For example, loss of outdoor recreation opportunities would decrease the appeal to tourists. Fewer tourists would mean less money spent in the service industry, which could mean fewer jobs.

1. Natural landscapes and public lands

The 2023 PFS proposed to build the mine on private land within and/or adjacent to ecologically and socially important public lands. These lands have extremely high biological diversity, including critical habitat for the endangered jaguar,

[108] *Green Valley News,* June 7, 2022 (Updated June 21, 2022.) https://www.gvnews.com/news/county-resolution-opposes-mine-project/article_76877fe6-e6bc-11ec-a585-a3144483d545.html

high value for recreation, and great importance as a source of water recharge for the surrounding aquifer and the Santa Cruz River.

a. The attraction of public land

Tucson is nearly surrounded by protected lands that are the foundation of the area's recreation and visitor economy. For example, the Coronado National Forest, which has large land holdings in Pima County, "welcomes millions each year" from around the world.[109]

Making the general case for the economic value of natural landscapes, Headwaters Economics states that:

> "Some types of federal lands, such as national parks, national monuments, and wilderness, can be associated with above-average economic growth. These lands by themselves do not guarantee economic growth but when combined with other factors, such as an educated workforce and access to major markets via airports, they have been shown to be statistically significant predictors of growth."

There is no doubt this observation explains the phenomenally strong Pima County economy, described in Section I.1.

Approximately 44% of Pima County is public land that offers recreation, environmental services, and other natural amenities. Nearly 15% of that 44% is state land, largely state trust land. The remaining 29.2% is federal land belonging primarily to the U.S. Forest Service, Bureau of Land Management (BLM), or National Parks System.[110]

In national parks and wilderness, natural ecosystems are highly protected, while lands in the national forest or BLM systems have differing levels of protection determined by their management plans and procedures set out in forest or BLM management rules. Additional protections may include requirements for agency review according to the National Environmental Protection Act (NEPA) and requirements of laws like the Endangered Species Act (ESA) and Clean Water Act. The national forest and BLM lands typically are rated as Level 3 in the USGS protected area classification system.[111]

Recognizing the economic and social value of protected public lands, in 2021 Pima County approved the Sonoran Desert Conservation Plan (SDCP), which designated lands that would be preserved in a natural state as mitigation for development elsewhere. Since 2001, Pima County has purchased over 180,000

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[109] Recreation.gov. Sitepass Selection for the Coronado National Forest. Accessed 6.22.2023. https://www.recreation.gov/sitepass/74388

[110] Pima County is home to Organ Pipe Cactus National Park as well as Saguaro National Park. County public land percentages are from Headwaters Economics. Economic Profile System. Living Near Public Lands. Pima County, AZ. 6.20.2023.

[111] USGS Gap Analysis Project: PAD-US Data Overview. https://www.usgs.gov/programs/gap-analysis-project/science/pad-us-data-overview. Accessed 9/25/2023.

acres using $174 million in Open Space Bonds approved by voters in 2004."[112,113] Those bonds, which have now protected a large amount of land for the greater Tucson area, are guided by the SDCP.

> "The award-winning Sonoran Desert Conservation Plan (SDCP) is Pima County's plan for balancing the conservation and protection of our cultural and natural resource heritage with our efforts to maintain an economically vigorous and fiscally responsible community. The SDCP considered the following elements: critical habitats and biological corridors, riparian areas, mountain parks, historical and cultural preservation, and ranch conservation. All five elements, along with fiscal analysis, were critical in forming a viable land management plan for Pima County."[114]

b. Outdoor recreation

Outdoor recreation[115] is a larger driver of the economy in Pima County than most other segments, notably the metal mining and processing industry. Its value to Pima County stretch into billions of dollars and it supports some 14,000 jobs (see calculations below). Because the outdoor recreation industry is so dominant, a relatively small decline on a percentage basis could do great harm that would reverberate in other sectors of the economy. Net in-migration, responsible for most of the population gains in Pima County, would fall. Non-labor income that the new in-migrants bring with them, which makes up about 50% of the income in Pima County, would also fall. People move to the greater Tucson area because they are drawn to the diverse and relatively pristine natural environments into which the proposed mine may simply not fit.

Unfortunately, there are no direct statistics characterizing local outdoor recreation in Pima county, but the federal Bureau of Economic Analysis (BEA) does have data for the country as a whole and for individual states. In 2021 the total value of outdoor recreation in Arizona was $9.82 billion dollars supporting more than 100,000 jobs and creating more than $5 billion in compensation.[116]

In order to interpret this statewide data in terms of Pima County, as a first order approximation we can multiply the number of recreation jobs in the state (100,000),

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[112] Pima County. About Conservation Lands. Accessed 6.20.2023.
[113] Coalition for Sonoran Desert Protection. Sonoran Desert Conservation Plan. Accessed 6.20.2023. https://www.sonorandesert.org/learning-more/sonoran-desert-conservation-plan/
[114] Pima County. The Sonoran Desert Conservation Plan. Accessed 6.20.2023. https://www.pima.gov/787/The-Sonoran-Desert-Conservation-Plan
[115] According to the Bureau of Economic Analysis, Outdoor Recreation is broken into conventional, other, and supporting. "Conventional ORSA activities include traditional outdoor activities, such as camping, hiking, boating, and hunting. Other ORSA activities include those that take place outside, such as gardening and outdoor concerts. Supporting ORSA activities are those that contribute to the core activities and include such things as construction, travel and tourism, local trips, and government expenditures." Bureau of Economic Analysis. Outdoor Recreation Satellite Account. 2021-Arizona. 2022. https://apps.bea.gov/data/special-topics/orsa/summary-sheets/ORSA%20-%20Arizona.pdf
[116] BEA. Outdoor Recreation Satellite Accounts, U.S. and the States, 2021. 11.9.2022. Page 19. Table 1.

for example, by the percentage of Arizonans who live in Pima County.[117] Using this approximation yields an outdoor recreation economy in Pima County that has $1.4 billion in value added, more than 14,000 jobs, and more than $700 million in income.

To get a sense whether our approximation is reasonable, we compared the results with the Audubon Society's study of recreation associated with the rivers, lakes, and streams, which has county-specific data. Audubon found that the 222,000 Pima County residents who participated in water-associated recreation generated 12,000 jobs, more than $88 million in local taxes, and $1.4 billion in economic output.[118] Both Audubon's estimate of jobs supported by recreation in Pima County (12,000) and our extrapolation from statewide data (14,000) are very close.

However, the fact that both we and Audubon came up with a figure of $1.4 billion is merely coincidental because the figures aren't comparable. Our $1.4 billion calculated from the BEA statewide analysis is *value added* and Audubon's number is the total of all money spent, *which includes costs*.[119] Of course we would not expect that they would be the same since Audubon was only looking at outdoor recreation associated with water, while we are trying to get at all of the outdoor recreation that happens in Pima County, which certainly includes water.

Based on our calculations, which are based on the BEA data for the state of Arizona with respect to pay per job, the mine's direct jobs equal about 3% of the outdoor recreation jobs in Pima County. The total of direct and secondary jobs equals a little less than 24% of outdoor recreation jobs (see Table 4).

Because miners average more per year than average Pima County workers, and outdoor recreation pays less than the average job, income from the 430 direct mining jobs would represent 6% of the outdoor industry wages, based on the BEA data for outdoor recreation in Arizona, and income from the 3,430 total mining jobs would represent 31% of outdoor industry wages (see Table 4). This analysis shows that the outdoor recreation industry in Pima County is significantly more important than the proposed mine, but it also shows that the proposed mine is a significant fraction of the size of the outdoor industry.

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[117] As a check on this methodology, we did the same thing for the Audubon report on Lakes, Rivers, and Streams since they broke Pima County specifically out. When the same comparison is made, Audubon believes that Pima represents between 10-11% of the state of Arizona for outdoor recreation associated with water. This is very close to the population break down that we used in the analysis above. This is not a strange result since Pima County is a very outdoor-oriented County.

[118] For this study the economic output was contributions to Arizona's GDP, household income, and tax revenue. Economic Output is the term that is used in the Audubon study. For a discussion of what economic output represents, please see the BEA. What is Productivity? Output. Accessed 9.8.2023. https://www.bls.gov/k12/productivity-101/content/what-is-productivity/what-is-output.htm . For the Audubon study please see: Southwick Associates. The Economic Impact of Arizona's Rivers, Lakes, and Streams. Prepared for Audubon. 2018. Page 6.

[119] Value added subtracts the costs out to present the value that is created by an industry. It is the total minus the costs.

Table 4.

	Jobs	Total Pay	% of Outdoor Jobs	% of Outdoor Pay
Outdoor Industry	14,445	718,920,939	100%	100%
Direct Mining	430	42,631,490	3%	6%
Total Mining	3,430	221,503,490	24%	31%

Source: BEA. Outdoor Recreation Satellite Accounts, U.S. and the States, 2021. 11.9.2022. Page 19. Table 1., and Hudbay. Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023. Page 1-18.

Table 4. shows the total jobs, total pay, and the relative size of the outdoor industry compared to the projected mining jobs from Hudbay.

Recreational opportunities that could be harmed by the mine include hiking, water-based recreation, and sky-gazing.

Hiking trails

The mine will cause some hiking trails to be closed and others, like a portion of the Arizona Trail, to be rerouted. For many, the sense of seclusion and the scenic viewscapes will be fundamentally changed by the sight of the mine and associated truck traffic, dust, light, and noise.

The Arizona Trail, which runs from the southern end of Arizona to the northern end, passes through the Copper World project area,[120] and mine construction would mean rerouting part of the trail. Multiple sections are within a few hundred feet of Hudbay's property, some as close as 20 feet, and the trail is within 1.5 miles of one of Hudbay's proposed mine pits.[121] Aside from the Arizona Trail itself, there are numerous other hiking trails that would be swallowed by the mine.[122]

Although there are no specific use statistics for the Arizona trail, we know that it enjoys massive use and support statewide:

> "In 2022, more than 2,250 volunteers reported more than 22,500+ hours of AZT (Arizona Trail) related work to the ATA (Arizona Trail Association). This is

[120] PimaMaps. Rosemont Mine. Accessed 6.22.2023. https://pimamaps.pima.gov/HtmlPubViewer/index.html?configBase=https://pimamaps.pima.gov/Geocortex/Essentials/PublicPM/REST/sites/rosemontsite/viewers/rosemontmap/virtualdirectory/Resources/Config/Default&layertheme=undefined
[121] PimaMaps. Rosemont Mine. Accessed 6.22.2023. https://pimamaps.pima.gov/HtmlPubViewer/index.html?configBase=https://pimamaps.pima.gov/Geocortex/Essentials/PublicPM/REST/sites/rosemontsite/viewers/rosemontmap/virtualdirectory/Resources/Config/Default&layertheme=undefined
[122] Ibid.

equivalent to more than 12 full-time staff members. Additionally, these hours correspond to more than $652,500 in donations."[123]

Additional evidence of the economic importance of trails is a recent study by the University of Arizona, in Tucson,[124] which found that residents used Arizona's trails for non-motorized recreation more than 83 million times in 2020. The economic value to the residents that used the trails was more than $8 billion per year.

> "Outdoor recreation amenities support the quality of life and health of individuals, communities, and local economies. Trail access for non-motorized and motorized recreation enriches the lives of community residents and visitors, providing an outlet for exercise, outdoor recreation, and transportation. Results of this study show that a large majority of Arizonans consider access to trails as important or very important in their decisions of where to live and where to visit for leisure, even for Arizonans that do not participate in trail-based outdoor recreation regularly. For communities seeking to attract and retain workforce, or to attract visitors, trail access is an important factor to consider."[125]

Of the top non-motorized trail-use areas in Arizona, Tucson ranks second, only slightly behind Phoenix, even though Phoenix has a much larger population.[126] Much-visited trails in the Santa Rita Mountains include the Bog Springs Trail, Old Baldy Trail, and the Cave Creek - Gardner Canyon Loop.[127] T

Water-based recreation

In 2018 Audubon commissioned a study to examine outdoor recreation on waterways in Arizona,[128] and found that outdoor recreation along waterways in Arizona annually generated $13.5 billion dollars. Pima County saw 222,000 Arizona residents participating in water-based outdoor recreation, which generated 12,000 jobs, more than $88 million in local taxes, and $1.4 billion in economic output.[129]

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[123] Arizona Trail Association. 2022 Annual Report. https://aztrail.org/wp-content/uploads/2023/03/2022-annual-report.pdf

[124] Duval, D., Frisvold, G. and Bickel, A. The Economic Value of Trails inn Arizona- A Travel Cost Method Study. University of Arizona. 2020.

[125] Duval, D., Frisvold, G. and Bickel, A. The Economic Value of Trails inn Arizona- A Travel Cost Method Study. University of Arizona. 2020. Page 50.

[126] Duval, D., Frisvold, G., Bickel, A. The Economic Value of Trails in Arizona. The University of Arizona. Agricultural & Resource Economics. 2020. Figure 8, Page 46.

[127] Visit Tucson: Santa Rita Mountains. https://www.visittucson.org/things-to-do/outdoors/mountains/santa-rita-mountains. Accessed 9.25.2025.

[128] Southwick Associates. The Economic Impact of Arizona's Rivers, Lakes, and Streams. Prepared for Audubon. 2018.

[129] For this study the economic output was contributions to Arizona's GDP, household income, and tax revenue. Economic Output is the term that is used in the Audubon study. For a discussion of what economic output represents, please see the BEA. What is Productivity? Output. Accessed 9.8.2023. https://www.bls.gov/k12/productivity-101/content/what-is-productivity/what-is-output.htm . For the Audubon study please see: Southwick Associates. The Economic Impact of Arizona's Rivers, Lakes, and Streams. Prepared for Audubon. 2018. Page 6.

Dark sky

The dark, clear skies of the greater Tucson area help make Pima County a special place for tourists. The Tucson Amateur Astronomy Association's website says, "The city has astronomy attractions to visit during the day, observatories to visit in the evening, or locations that enable you to enjoy the night sky on your own or with local guides."[130] The City of Tucson is an astronomy-oriented city that enacted an outdoor lighting ordinance in 2012 "that requires fully shielded lighting and sets limits on the total light produced at night, especially in natural areas and areas close to astronomy sites."[131]

One of the best star-gazing sites recommended by the Tucson Amateur Astronomy Association is Empire Ranch,[132] located off State Highway 83, approximately 8 miles from the Hudbay's proposed Rosemont Pit on the east side of the Santa Ritas. Because Hudbay has not released any information on its lighting plan, nor is there any NEPA analysis that would analyze lighting effects, it is hard to be specific about how the mine would alter sky viewing, but it seems certain that mine lighting would greatly diminish the night-sky experience.

We can get some idea of the magnitude of the effect from the analysis in the 2013 Final Environmental Impact Statement (FEIS) for the Rosemont Copper Project, a smaller mine planned at that time for part of the Copper World-Rosemont footprint. Effects projected in the FEIS included:

- At the Whipple Observatory Viewpoint there would be increased sky glow[133] of 524% at the horizon that would be clearly visible.[134]
- At the Sonoita Viewpoint there would be increased sky glow of 363% at the horizon that would be clearly visible to the average naked-eye viewer.[135]
- At the State Route 83 Viewpoint the sky brightness at 5 degrees over the mine site would increase by more than 400% over existing conditions.[136]

[130] Tucson Amateur Astronomy Association. https://tucsonastronomy.org/tucson-stargazing. Accessed 12.27.2023.
[131] DarkSky. Nights Over Tucson: How the Tucson, Arizona, LED Conversion Improved the Quality of the Night. https://darksky.org/news/nights-over-tucson. Accessed 12.27.2023.
[132] Tucson Amateur Astronomy Association. https://tucsonastronomy.org/tucson-stargazing. Accessed 12.27.2023.
[133] "Sky Glow is a result of light fixtures that emit a portion of their light directly upward into the sky where light scatters, creating a diffuse glow...This light can then interfere with sensitive astronomical instruments designed to capture light from distant stars, nebulae, and galaxies." Dark Sky Defenders. What is light Pollution? Accessed 8.1.2023. https://www.darkskydefenders.org/light-pollution.html
[134] Forest Service. Final Environmental Impact Statement for the Rosemont Copper Project. 2013. Page 761.
[135] Forest Service. Final Environmental Impact Statement for the Rosemont Copper Project. 2013. Page 761.
[136] Forest Service. Final Environmental Impact Statement for the Rosemont Copper Project. 2013. Page 762.

Wildlife

Finally, the mine will cut one of the most important wildlife corridors in the United States that connects the Santa Rita Mountains with other "Sky Islands" in Arizona and Sonora, Mexico. This wildlife highway has allowed endangered animals, including the jaguar, to enter the United States.[137] The presence of high-profile predators like the jaguar and other threatened and endangered species helps draw people who value wildlife and the natural environment to move to Pima County and make investments in the outdoor recreation industry.

2. Roads and traffic

Because neither a mining plan, a traffic study, nor an Environmental Impact Statement and associated expert studies have been completed, we do not know the details of the route that mine trucks will use to ship out the copper concentrates and possibly purified copper cathodes.

The PFS states that mine traffic will use the west-side Santa Rita Road as its primary transportation corridor instead of the east-side SR 83 route proposed in the 2013 FEIS.[138] The Santa Rita Road connects the site of the mine's proposed processing facilities on the west side of the Santa Rita Mountains with the town of Sahuarita, approximately 11 miles west of the mine site. As it approaches the town, Santa Rita Road intersects Sahuarita Road, which has direct access to Interstate-19.

The Santa Rita Road is currently a mostly unpaved, lightly used dirt road that bisects the 50,000-acre Santa Rita Experimental Range (SRER) before entering the town of Sahuarita as a paved, two-lane road. The SRER is owned by the Arizona State Land Department and required by state law to be operated for "ecological and rangeland research." The range is managed by the University of Arizona. The SRER was part of Coronado National Forest until 1988, when the state obtained it as part of a land exchange with the federal government.

Once mine trucks reach Sahuarita Road, there's no indication in the PFS where they would go next. But for trucks carrying copper concentrate or possibly cathodes the options are: a) travel south on Interstate 19 to Nogales, Sonora; b) head north into Tucson to offload on trains at the Port of Tucson; or c) offload on a potential future rail siding in Sahuarita on a rail line that goes to Nogales and further south to Guaymas, Sonora, where there is a major port that already exports copper concentrate from other Arizona mines.

The previous plan in the 2022 PEA proposed to mine the *east* side of the mountains, in which case Hudbay would have travelled out from the mine using the utility

[137] Boydston, E. and Gonzalez, C. Sexual Differentiation in the Distribution of Northern Jaguars (Panthera onca). USDA Forest Service Proceedings RMRS-P-36. Page 51. 2005. https://www.fs.usda.gov/rm/pubs/rmrs_p036.pdf

[138] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 1-14.

maintenance road and then along the winding, two-lane scenic Sonoita Mountain View Highway (SR 83) to the east of the mine at milepost 46.[139] In this case the towns of Sonoita and Vail would have experienced the increased truck traffic. It is possible that both routes could be used in the future, with Santa Rita Road servicing the west side pits and SR 83 the east side.

Under Hudbay's current plan, an unknown number of mining trucks would pass through the Sahuarita Highlands community next to Santa Rita Road on their way to the Sahuarita Road intersection, decreasing the quality of life due to dust, noise, and the danger of accidents. Since the trucking route would also cross the entire Santa Rita Experimental Range, where Santa Rita Road is now unpaved, the mine traffic would likely interfere with the isolated, open-space nature of the range that is essential for ecological and rangeland studies.

There have been no environmental, economic or traffic impact studies of Hudbay's planned use of the Santa Rita Road on the SRER, Sahuarita or the I-19 interchange. The lack of environmental reviews raises questions of who will pay to maintain the unpaved section of the Santa Rita Road through the SRER. There also may be pressure from the mine to pave the road, which would likely cause additional disturbance to the natural ecosystem of the SRER.

Trucks hauling copper concentrate may also play a role in disseminating dust containing dangerous heavy metals.[140] An indicator of this possibility can be seen in the ongoing transport of limestone from the Cimbar Performance Minerals' limestone and marble mine on the west side of the Santa Rita Mountains. According to local sources that travel on this road on a regular basis, the limestone company's trucks take the same northeast route along Santa Rita Road that the Copper World trucks would take, and the sides of the road near the Cimbar mine are white with limestone dust that has blown off the trucks.

Studies in other parts of the world have found that transport of copper concentrate has released heavy metals that contaminate soil. For example, a study in Peru found elevated levels of metals along a railroad route 50 km from the mining district and surmised the cause to be spillage and/or wind-blown dust.[141]

The now abandoned 2013 Rosemont FEIS laid out the number of truck trips per day, and, since has been no additional formal public analysis, we are using the FEIS as an incomplete reference:

> "As also stated in chapter 2, mine related traffic on SR 83 during active mining would primarily consist of trucks carrying supplies to the project area,

[139] Forest Service. Final Environmental Impact Statement for the Rosemont Copper Project. 2013. Page 921.
[140] Emily Onello et al., "Sulfide Mining and Human Health in Minnesota," *Minnesota Medicine* November-December (2016).
[141] James B. Molloy et al. 2020. "Citizen Science Campaign Reveals Widespread Fallout of Contaminated Dust from Mining Activities in the Central Peruvian Andes," *Geology* 48, no. 7 (July 1, 2020): 678–82, https://doi.org/10.1130/G47096.1.

> trucks carrying concentrate and copper cathodes (with the exception of the Barrel Alternative, which would not produce cathodes) from the project area, and employee traffic. Approximately 100 to 120 round trips of related truck traffic would occur daily. Copper concentrate shipments would form the largest number of routine truck trips, with approximately 56 round trips per day, 7 days per week."[142]

These estimates give an idea of the magnitude of traffic. At that time the mine was expecting 56 round trips per day, seven days per week to ship copper concentrate, in addition to roughly another 50 trips per day for shipping copper cathodes and other purposes. Because the new 2023 PFS plan proposes to produce 100% concentrate for the first four years, and because concentrate is high volume compared to pure copper cathodes, truck volume would likely be high.

If Hudbay sticks to its plan to begin producing lower-volume cathodes from 58% of their concentrate in year five, truck traffic could be reduced unless overall production of concentrate increases. Figure 22-5 in the PFS indicates an increase from 80,000 tons in Year 4 to 87,000 tons in Year 5, to 109,000 tones in Year 6, and then levelling off at 96,000 tons per year for years 7 to 10. Because the PFS doesn't detail truck capacity or relative volume of concentrate versus cathodes, we cannot be sure how the proposed increase in mined ore in Year 6 would affect the number of truck trips. The PFS also predicts selling excess sulfuric acid produced on-site that would also require trucking.[143]

Given this analysis, it is unclear how the final daily mine traffic would change when compared to the 2013 FEIS. Hudbay's PFS does not disclose the frequency of trips for moving workers, supplies, concentrate and possibly copper cathodes over the Santa Rita Road. The 2013 FEIS for the Rosemont Mine estimated that "approximately 100 to 120 round trips of related truck traffic would occur daily. Copper concentrate shipments would form the largest number of routine truck trips, with approximately 56 round trips per day, 7 days per week."[144]

If Hudbay initiates its Phase II, they would do extensive mining on the east side, likely similar to what Hudbay proposed in its 2022 PEA. This assessment contains a plan for extensive east-side development with access via scenic SR 83, in which case the towns of Sonoita and Vail would experience increased heavy truck traffic.

3. Competition for water

a. Pre-existing water users

The Santa Rita Mountains provide both surface and groundwater to downstream natural ecosystems, agriculture, and residential developments in the Santa Cruz

[142] Forest Service. Final Environmental Impact Statement for the Rosemont Copper Project. 2013. Page 951.
[143] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 22-4 and1-16 respectively.
[144] Forest Service. FEIS for the Rosemont Copper Project. 2017. Page 951.

River Basin. In general, ground water flows from the mountains into the valley and then from the south to the north.[145] If the mine interferes with natural surface flows or pumps enough water to significantly diminish underground supplies, both people and wildlife will suffer.

Wildlife

Water flowing off the Santa Ritas' supports ephemeral streams, which only run on the surface during monsoon seasons, as well perennial streams, wetlands, and ponds. Not only are the surface waters vital wildlife habitat, but ephemeral streams (washes) are as well because they support denser and more varied vegetation than surrounding dryer areas.

According to the Sky Island Alliance, "waters running off from the Santa Ritas feed Cienega Creek as it runs through the heart of Las Cienegas National Conservation Area. Sonoita Creek is fed by the eastern and southern flanks of the mountains. Patagonia-Sonoita Creek Preserve also encompasses riparian habitat fed in part by runoff from the Santa Ritas. Owned by The Nature Conservancy, the preserve is home to rare fish, frogs and plants, and over 200 species of birds have been recorded there."[146]

Human use

People in surrounding communities like Sahuarita depend on wells for daily use and/or agriculture within the area where Hudbay will be pumping out enormous amounts of groundwater. As detailed in Section V.3c below, Hudbay plans to pump enough water to supply roughly 54,000 to 108,000 residents.

b. Water sharing and supply.

Competition for Colorado River water.

The West is experiencing a mega-drought. From 2000 to 2021 Colorado River flows dropped by about 10%, equal to the storage of Lake Mead, the largest water reservoir in the U.S.[147] Water shortages will continue to worsen in the western U.S. because the world is locked into at least another 1.5 degrees C. of warming.[148]

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[145] Arizona Department of Water Resources. Regional Groundwater Flow Model of the Tucson Active Management Area, Arizona. Model Update and Calibration. Modeling Report 24. April 2013. Figure 21. Page 50.
[146] Sky Island Alliance. Nogales Ranger District: Chapter 5: Santa Rita Ecosystem Management Area. https://skyislandalliance.org/wp-content/uploads/2014/11/SantaRita_EMA.pdf. Accessed 9.25.2023.
[147] Bass, B., Goldenson, N., Rahimi, S., & Hall, A. Aridification of Colorado River Basin's snowpack regions has driven water losses despite ameliorating effects of vegetation. *Water Resources Research*, *59*, e2022WR033454. 2023. https://doi.org/10.1029/2022WR033454
[148] IPCC. Climate change widespread, rapid, and intensifying. Newsroom. 8.9.2021. Accessed 8.10.2023. https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/

The shortfall in Colorado river water has caused the federal government and the states in 2023 to renegotiate the allocations made under the Colorado Compact.[149] The new allocations will only be in place until 2026, when the compact will be renegotiated.[150]

Under this temporary agreement, the Federal Government is paying irrigation districts, Native American Tribes, and cities more than $1 billion for voluntary cuts in how much water they use, but such voluntary cuts may not be enough in the long term, and nonvoluntary restrictions are beginning. In June of 2023 the state of Arizona began denying developers in the suburbs of Phoenix permits to build residential homes because of the lack of water.[151] This current shortfall has been more than a century in the making.

The Colorado River Compact.

Water is a precious commodity in all of the western U.S., but particularly so in Arizona. Much of Central Arizona gets its water from the Colorado River, and that allocation of water from Lake Mead is governed by the Colorado River Compact.[152] Arizona is part of what is collectively known as the "Lower Basin" states, which include Arizona, California, and Nevada. The Upper Basin and Lower Basin were each allotted 7.5 million acre-feet of water annually, for a total of 15 million acre-feet of water, of which Arizona was allotted 2.8 million acre-feet. Arizona has a long history of failing to balance its water needs against the natural limits of the amount of water that is available in different parts of the state.

> "In 1968 central Arizona was over drafting an estimated 2.5 million acre-feet annually, lowering aquifer levels by 300 to 400 feet in some areas, with adverse effects such as land subsidence."[153]

At the same time, the Central Arizona Project (CAP) was passed by Congress as part of the Colorado River Basin Project Act of 1968.[154] However, in the decade after its

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[149] Flavelle, C. A Breakthrough Deal to Keep the Colorado River From Going Dry, for Now. The New York Times. 5.22.2023. https://www.nytimes.com/2023/05/22/climate/colorado-river-deal.html?searchResultPosition=5

[150] U.S. Department of the Interior. Biden-Harris Administration Announces Historic Consensus System Conservation Proposal to Protect the Colorado River Basin. 5.22.2023. Accessed 8.3.2023. https://www.doi.gov/pressreleases/biden-harris-administration-announces-historic-consensus-system-conservation-proposal

[151] Flavell, C. and Healy, J. Arizona Limits Construction Around Phoenix as Its Water Supply Dwindles. The New York Times. 6.1.2023. https://www.nytimes.com/2023/06/01/climate/arizona-phoenix-permits-housing-water.html

[152]Gelt, J. Sharing Colorado River Water: History, Public Policy and the Colorado River Compact. Aroyo, vol. 10 no.1. Water Resource Research Center. 8.1.1997.Accessed 8.3.2023. https://wrrc.arizona.edu/publication/sharing-colorado-river-water-history-public-policy-and-colorado-river-compact

[153] McGreak, B. and Eden, S. Arizona Groundwater Management-Past, Present and Future. Arroyo 2021. 2021. Page 2.

[154] CAP. Colorado River Basin Project Act. Accessed 6.23.2023. https://www.cap-az.com/about/history-of-cap/colorado-river-basin-project-

passage, Arizona still had not seen substantial deliveries of water, and the federal government began to send signals to Arizona that if it did not figure out its groundwater over drafting, it would not see the completion of the CAP.

Arizona's Groundwater Management Act

Arizona very much wanted and needed the water that CAP promised to bring and responded to pressure from the federal government by passing the Groundwater Management Act in 1980. "The act demonstrated Arizona's ability to manage its water resources and succeeded in convincing the federal government to fund completion of the CAP."[155] Since CAP was completed, giving Arizona access to its share of the Colorado River, which totals some 2.8 million acre-feet of water per year, Arizona has enacted more stringent water use rules.[156]

Part of the act requires Arizona cities and developers to demonstrate that they have a renewable 100-year supply of water before they can proceed with development plans.[157] However, when the act passed, the mining industry had the political clout to be exempted so that mines *outside* of the Active Management Areas (AMA) can pump as much water as they want. We want to be very clear in stating that *inside* the AMAs, and the proposed Copper World mines are in the Tucson AMA, mines *cannot pump* unlimited groundwater without a permit. This makes sense given that Hudbay has a permit to pump water in the Tucson AMA and the purpose of an AMA is to regulate the amount of water that is used in these high population density areas.

The Central Arizona Project

The history of water in Arizona is a story of overuse. As municipalities grew and desert land was irrigated for agriculture, water diversions and over-pumping of groundwater dried up rivers and streams. Growth outstripped the water supply and for decades much of central Arizona has not been able to subsist on local sources alone.

The result of this mega-drought is that the Colorado Compact had to be renegotiated.[158] It is likely that the Colorado River never had as much water in it, at

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act/#:~:text=On%20September%2030%2C%201968%2C%20President,to%20central%20and%20southern%20Arizona.

[155] McGreak, B. and Eden, S. Arizona Groundwater Management-Past, Present and Future. Arroyo 2021. 2021. Page 2.

[156] Witcher, T. The Storied history of the Central Arizona Project. American Society of Civil Engineers. 3.1.2022. Accessed 6.23.2023. https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/issues/magazine-issue/article/2022/03/the-storied-history-of-the-central-arizona-project

[157] Arizona Department of Water Resources. Water Your Facts. Arizona Water Facts. Accessed 6.23.2023. https://www.arizonawaterfacts.com/water-your-facts#:~:text=Arizona%20has%20the%20right%20to,annually%20of%20Colorado%20River%20water.

[158] Flavelle, C. A Breakthrough Deal to Keep the Colorado River From Going Dry, for Now. The New York Times. 5.22.2023. https://www.nytimes.com/2023/05/22/climate/colorado-river-deal.html?searchResultPosition=5

least historically, as was allotted to the Upper and Lower Basin States, but the writing has been on the wall for some time now. The bathtub rings of Lake Mead and Lake Powell are easy for even the casual observer to interpret, and the Deadpool[159] elevation news stories have been running rather continuously for years now. Bass found that from 2000-2021 that the megadrought has decreased the water available by about 10%, which is equal to the storage of Lake Mead.[160] This rather remarkable finding, that in 22 years the Colorado River has lost a volume of water that is equal to the largest reservoir of water in the U.S.,[161] should be a rather sobering result. Unfortunately, this is the new normal that the western U.S. will have to become accustomed to, because even if the world stopped adding greenhouse gasses to the Earth's atmosphere today, we are locked into at least 1.5 degrees C. of warming.[162]

The West is in drought, and the Colorado River has been overpromised. The new deal for the Colorado River, which dictates the water each state gets, will only last until 2026 and then it will be renegotiated.[163] Currently the Federal Government is paying different groups for voluntary cuts in water use that largely comes from farmers and Native American Tribes, but the future is an unknown. In June of 2023 the state of Arizona began denying developers in the suburbs of Phoenix permits to build residential homes because of the lack of water.[164] It is not that it is impossible for developers to purchase water rights from, for example, farmers or Native American Tribes, it is simply that they are not guaranteed water from their municipalities and ultimately the state of Arizona. This long and complex history of water and development in the Arizona deserts sets the stage for a discussion of the water that Hudbay states it will use in its proposed mines and ore processing facilities.

c. Hudbay's proposed water use.

Analysis of how Hudbay's water use will affect other users and the environment is difficult because Hudbay's mining plans continue to change and because the 2023 PFS does not contain numbers on how much water they propose to use. However,

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[159] Deadpool is the elevation where dams like Glenn Canyon and Hoover can no longer generate electricity because the water level is too low.
[160] Bass, B., Goldenson, N., Rahimi, S., & Hall, A. Aridification of Colorado River Basin's snowpack regions has driven water losses despite ameliorating effects of vegetation. *Water Resources Research*, *59*, e2022WR033454. 2023. https://doi.org/10.1029/2022WR033454
[161] National Parks Service. Overview of Lake Mead. Accessed 8.10.2023. https://www.nps.gov/lake/learn/nature/overview-of-lake-mead.htm#:~:text=At%20full%20pool%2C%20Lake%20Mead,(Paulson%20and%20Baker%201983).
[162] IPCC. Climate change widespread, rapid, and intensifying. Newsroom. 8.9.2021. Accessed 8.10.2023. https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/
[163] U.S. Department of the Interior. Biden-Harris Administration Announces Historic Consensus System Conservation Proposal to Protect the Colorado River Basin. 5.22.2023. Accessed 8.3.2023. https://www.doi.gov/pressreleases/biden-harris-administration-announces-historic-consensus-system-conservation-proposal
[164] Flavell, C. and Healy, J. Arizona Limits Construction Around Phoenix as Its Water Supply Dwindles. The New York Times. 6.1.2023. https://www.nytimes.com/2023/06/01/climate/arizona-phoenix-permits-housing-water.html

we can make an estimate based on numbers in the June 2022 PEA and the state water permit they currently hold.

In the June 2022 PEA, Hudbay proposed to consume an annual average of 13,000 acre-feet per year of groundwater pumped from wells next to the Santa Cruz River for 44 years. The 2023 PFS provides no analogous information other than stating that the company has a permit from the State Department of Water Resources to use up to 6,000 acre-feet (2 billion gallons) per year.

> "Copper World, Inc. has a permit to withdraw groundwater for mineral extraction and metallurgical processing in the amount of 6,000 acre-feet per year for 20 years. This amount may change when the engineering studies are finalized."[165]

One of the most significant changes in Hudbay's 2023 plan is that during at least the first four years of production they will no longer produce finished copper on-site but instead will export unrefined copper concentrate to overseas copper smelters and refineries. This will lower the amount of water and electric power the company will need compared to the 2022 plan during the initial four years.

Beginning in the fifth year, the PFS proposes a $367 million "concentrate leaching facility" that will allow it to convert about 58% of the copper concentrate to metal. If Hudbay builds the proposed leach facility, which is not certain, it will likely increase water consumption into the range of the previous 2022 estimate of 13,000 acre-feet per year. Considering the preceding facts, it is likely that during the first four years Hudbay will use in the neighborhood of 6,000 acre-feet (2 billion gallons) per year, rising to at least 13,000 acre-feet per year if and when the leach facility is built.

An acre-foot is the amount of water that would cover an acre of land one foot deep, or 325,851 gallons.[166] According to the Arizona Department of Water Resources in 2022, on average 3.5 homes use about an acre-foot of water every year. Our estimates of how much water the project is likely to use then translate into enough water to supply 21,000 Arizona homes every year during the first four years, rising to perhaps double that if the refining facility is built.

Since, according to the U.S. Census Bureau, there are 2.58 people per home in Arizona, this would equate during the project's first four years to enough water per year for 54,180 people, perhaps rising to double that (108,360 people) if the concentrate leaching facility were to be built.[167] Given the desperate measures to cut water consumption being under-taken by the federal government, states, and municipalities, societal priorities appear to have been skewed to permit a new mine that would use the same amount of water as roughly 54,000 to 108,000 Arizonans.

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[165] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 18-2.
[166] Arizona Department of Water Resources. How many homes in Arizona, on average, share an acre-foot of water each year? 4.19.2021 https://new.azwater.gov/news/articles/2021-19-04
[167] Census. Quick Facts: Arizona. 7.1.2022. Accessed 6.22.2023. https://www.census.gov/quickfacts/AZ

Here we will calculate the dollar value of what amounts to a water subsidy for the mine. Currently, municipalities in Arizona are paying around $50-$150 for one acre-foot of water and around $150 per acre-foot of CAP water.[168] However, Arizona is reaching the limit of that cheap water, in part because under current drought conditions there isn't enough Colorado River water to meet the needs of all the states.

Theoretically, new water sources could include desalinization in the Sea of Cortez in a joint project between the U.S. and Mexico at a cost of $2,000 per acre foot or more, or perhaps desalinating brackish groundwater in Arizona at a cost of $600-$1,200 per acre foot.[169] While even a few years ago these water prices would have seemed impossibly high, the new agreements being reached by the Biden administration have seen water rights holders paid more than $500 per acre-foot to not use their water.[170] This has, almost overnight, reset the current value of water in Arizona and much of the Lower Basin.

To calculate a range of values for Hudbay's "water subsidy," at the low end we can use the CAP water price ($150 per acre-foot) and the lowest predicted consumption of water by Hudbay (6,000 acre-feet), that puts the value of water Hudbay would use at just under $1 million per year for the 20-year life of the mine. On the high end is the $521 per acre-foot that the federal government is paying some users not to use and the higher water consumption prediction for Hubay (13,000 acre-feet), which puts the value of their free water at $7 million per year for the life of the mine. These values will likely increase in the future as water resources become scarcer, the Colorado River Compact is revised, or future payments to entities for not using water increase.

Many cities in Arizona, even where CAP water is available, still use groundwater that they pump locally. For example, the Sahuarita Water Company, which supplies water to 14,000 residents in Pima County, uses "groundwater drawn from the aquifer" directly west of the proposed mine.[171] Since Hudbay currently has a permit to pump 6,000 acre-feet of water annually (their permit runs out 2028),[172] it is likely that the

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[168] Nugent, C. Arizona Faces an Existential Dilemma: Import Water or End Its Housing Boom. Time. 1.20.2023. Accessed 6.23.2023. https://time.com/6248517/arizona-growing-population-drought-housing/ and Central Arizona Project. Final 2019-2024 Rate Schedule. 6.7.2018. Accessed 8.3.2023. https://library.cap-az.com/documents/departments/finance/Final-2019-2024-CAP-Water-Rate-Schedule-06-07-18.pdf

[169] Faller, M. The Future of Water in Arizona: ASU experts predict how water consumption might look in our state, based on the science of today. Arizona State University. 11.5.2022. Accessed on 6.23.2023. https://news.asu.edu/20221115-arizona-impact-future-water-arizona

[170] According to Bittle the value is $521 per acre-foot. Bittle, J. At last, states reach a Colorado River deal: Pay farmers not to farm. 5.22.2023. Accessed 8.7.2023. https://grist.org/drought/colorado-river-deal-arizona-nevada-california-conservation-agriculture/

[171] Sahuarita Water Company. About us. Accessed 9.5.2023. https://sahuaritawater.com/about-us/#:~:text=The%20source%20of%20SWC%20water,aquifer%20system%20below%20the%20development.

[172] The proposed mine is inside of the Tucson Active Management Area for water in Arizona. Because of this Hudbay had to get a permit for the water that they can pump. Hudbay. Preliminary Economic Assessment. Copper World Complex, Pima County, Arizona USA. 5.1.2022. Page 20-172.

municipal wells around the proposed mine will have less water available. This is substantiated by the 2013 FEIS for the previously planned Rosemont Mine, which predicted that surrounding wells would produce less water for 140 years after the mine stopped pumping, based on use of only 4,700-5,400 acre-feet per year by the mine, compared to the 6,000 to 13,000 expected for Copper World.

> "Groundwater levels would decrease up to an additional 90 feet from the pumping, declining at a rate of 1.5 to 3.5 feet per year above and beyond existing groundwater declines. The geographic extent of the drawdown would be 3 to 4 miles from the Rosemont production wells during the first 20 years of pumping; the geographic extent of impacts would continue to expand an additional 1 to 2 miles for up to an estimated 140 years after completion of pumping. An estimated 500 to 550 registered wells are located within this area of drawdown; specific impacts to individual wells, if any, cannot be identified."[173]

If the proposed mine were to pump significantly more than what was modeled for the FEIS, as seems likely, the drawdown of groundwater would be significantly increased. Without groundwater modeling for the current project analogous to that done for the FEIS, it's difficult to know for certain how much ground water would no longer be available for local municipalities, but there would conceivably be almost three times the water volume pumped out of the proposed mine's wells when compared to the 2013 FEIS.[174] If the time scale is linear with respect to the recharge of the groundwater, then it will take almost 400 years to recharge the local area's groundwater after the mine has stopped pumping, and it is likely that many more local wells will be affected.

Augusta, the company that previously owned the Rosemont Copper Mine and sold the project to Hudbay, made promises to the local community to recharge "105% of the groundwater used during operations."[175] Augusta, in an attempt to show the local area that they were serious about recharging the water that they would use, as of 2010 had stored 45,000 acre-feet of water by pumping it underground.[176] However, this recharge was in a different basin from the one where Hudbay is planning to draw water. This means that this recharged water will not help people who need to draw water from the same basin the mine is pumping from.

In addition, as of 2017, Hudbay also has a CAP allocation of 1,124 acre-feet of water that could be used in the mine or could be used to offset some of its groundwater

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[173] Forest Service. FEIS for the Rosemont Copper Project. 2017. Page xxix.
[174] Our calculations indicate that 13,151 acre-feet of water would be used by Hudbay based on their "fresh water consumption" from page 17-151 of the PEA. In the 2013 FEIS the water was assumed to be 4,700 to 5,400 acre-feet of water per year and the mines would pump for 20 years. This yields a ratio of about 2.8.
[175] Augusta. ROSEMONT COPPER PROJECT FORM 43-101F1 TECHNICAL REPORT. 8.28.2012. Page 185. https://www.sec.gov/Archives/edgar/data/1353123/000106299312003366/exhibit99-1.htm#page_198
[176] Augusta. ROSEMONT COPPER PROJECT FORM 43-101F1 TECHNICAL REPORT. 8.28.2012. Page 185. https://www.sec.gov/Archives/edgar/data/1353123/000106299312003366/exhibit99-1.htm#page_198

pumping.[177] However, that water currently cannot be delivered to the mine or the pumping area because there is no pipeline. Finally, as we laid out earlier, there is about to be a rather contentious overhaul of the Colorado River Compact that may well decrease the amount of CAP water available to the mine.

If the proposed mine wants to pump more water than their permit now allows, because their wells are in the Tucson Active Management Area for water, they will have to get a new water permit. Mines that are outside of the five Active Management Areas are subject to the "Reasonable Use Doctrine" under the Arizona Groundwater code which allows more liberal water pumping, but those rules do not apply to the Tucson Active Management Area that the proposed mine's wells are situated.[178] Although it is unclear if Arizona will essentially "rubber stamp" an increase of groundwater use of this level, there is specific language for the state of Arizona that could be used to deny the permits.

" Applications for permit to appropriate public water must be approved by the Director of ADWR, and will be approved or denied based on whether or not:

- The proposed use will interfere with vested or existing water rights;

- The director perceives the use to "threat(en) public safety;"

- The use threatens the public interest and welfare.

ADWR does not directly have rights to change the amount of water allotted to a mine, but for permits that must be renewed, ADWR may consider other users and any interference a mine poses when deciding whether or not to reapprove a mine's water allocation."[179]

It is certainly conceivable that the proposed mine would interfere with other existing water rights, threaten public safety through this interference, and threaten public interest and welfare as local wells dried up for potentially many hundreds of years. If the proposed mine takes 3 times as much groundwater as what was modeled in the 2013 FEIS, then the Arizona Department of Water Resources should have to take a hard look following their own criteria.

[177] Bureau of Reclamation Phoenix Area Office. Green Valley Area Water Supply Study Prepared for the Upper Santa Cruz Providers and Users Group Pima County, Arizona. June 2017. Page 4. https://www.usbr.gov/lc/phoenix/programs/GREENVALLEY/GVWSSPrelimAsmnt.pdf

[178] Colombia Center on Sustainability. Legar Framework Governing Water Use: U.S.-Arizona. 2016. Pages 2-5. Accessed 9.5.2023. https://ccsi.columbia.edu/sites/default/files/content/docs/our%20focus/Water-Template-USA-Arizona.pdf and Arizona Department of Water Resources. Tucson Active Management Zone. 9.8.2003. Accessed 9.5.2023. https://infoshare.azwater.gov/docushare/dsweb/Get/WellRegDoc-371992/Tucson_AMA_Map.pdf

[179] Colombia Center on Sustainability. Legar Framework Governing Water Use: U.S.-Arizona. 2016. Pages. Page 9. Accessed 9.5.2023. https://ccsi.columbia.edu/sites/default/files/content/docs/our%20focus/Water-Template-USA-Arizona.pdf

4. Property values

The economic impact of mines has been studied at length. In one important meta-analysis, Menegaki reviewed 44 peer-reviewed articles,[180] of which 38 presented external costs from mining, while only 6 of them presented external benefits (2 presented both external costs and benefits).[181] Put in a slightly different way, the authors of these economic studies focused primarily on the *costs* associated with the mines. We used Menegaki's list of 44 studies to identify specific methods of valuation that were most applicable to the impact of a copper mine on property values. We implement those methods in this section.

We observe in passing that *benefits* from mines are much more commonly quantified than costs because it is relatively easy to quantify jobs, wages, and tax revenues and more challenging to evaluate things like the mine's effects on in-migration or housing prices. For this reason, Power Consulting routinely sees "benefits- only" analyses of mining projects, including environmental impact statements or mining plans that analyze projects as if there were no costs. A more balanced approach would be to assess costs that include, for example, reductions in housing values.

Rivera studied changes in the cost of housing rents when copper mines started up in local communities in Chile.[182] Using the data from 7,500 households in 224 cities across Chile from 2011 to 2015, they found that when a conventional mine, like Hudbay's proposed open-pit mine, opened near a city, the rent was driven lower by 18 to 26% compared to cities where there was no mining.

Williams observed that decreases in property values caused by multiple mines in a county can be additive.[183] *Each* additional surface coal mine in a county decreased residential property values an additional 0.34 to 1.7%. Assuming a similar relationship would hold for hard rock mining in Pima County, we could expect the Copper World project to add to decreases in property value caused by other hard rock mines already built near Sahuarita.

In 1992 Kim looked at how changes in air quality and view degradation from copper mining changed property values in Green Valley, Arizona, population 21,000.[184] Using

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[180] Menegaki, M., and Dimitris, D. A systematic review of the use of environmental economics in the mining industry. *Journal of Sustainable Mining*: Vol. 19 : Iss. 4 , Article 5. 2020.
[181] Menegaki, M., and Dimitris, D. A systematic review of the use of environmental economics in the mining industry. *Journal of Sustainable Mining*: Vol. 19 : Iss. 4 , Article 5. 2020. Table 7. Page 263.
[182] Rivera, N. Is Mining an Environmental Disamenity? Evidence from Resource Extraction Site Openings. Department of Economics Working Papers WP 2019-05. University of Alaska Anchorage. 11.13.2019.
[183] Williams, A. The Impact of Surface Mining on Residential Property Values: A Hedonic Price Analysis. University of Tennessee-Knoxville. May 2011.
[184]The Kim et al. journal article is particularly applicable to this study because it is studying the impact of a copper mine on the same local residents. It was vetted and selected by the review article from Menegaki and it is within an acceptable time period. Kim, H. and Harris, D. Air Quality and View Degradations due to Copper Mining and Milling: Preliminary Analysis and Cost Estimates for Green Valley, Arizona. Nonrenewable Resources. Vol. 5, No.2. 1996.

what is called a hedonic analysis, Kim asked residents how much they would be willing to pay for houses, and then he ground-truthed those values against the real estate market. Kim found that the deterioration of air quality drove house value down $13,000 per household and a view degradation drove perceived value down $5,000 per household.[185] It should be pointed out the air quality degradation associated with the mine was significantly (2.6 times larger) than the viewscape degradation. Kim then combined these two perceived decreases to come up with a total impact of $116 million to $169 million in 1996.

We can get some validation of Kim's 1992 work by examining property values in Green Valley in 2000 and comparing them to 2022 values. Kim had postulated that there would be a decline in property values of $5,000 for the viewscape costs and $13,000 for air pollution. Using the Census data for home values from 2000[186] and comparing it to the 2017-2021 census,[187] there was no significant increase in median property values in Green Valley from 2000 to 2021 once the 2000 data is escalated to 2022 dollars.

This is interesting because during the same period in Pima County, which includes the town of Green Valley, property values increased by about 12%, or about $23,000 (using the same median value for home prices escalated to 2022 values). Although we cannot be sure whether the failure of prices in Green Valley to keep up with the general rise in Pima County was due to the nearby mines, it fits well with Kim's prediction. The cost Kim found being imposed on Green Valley residents (about $35,500 in 2022 dollars) is relatively close to the observed difference in Pima County compared to Green Valley ($23,000).

What local factors might similarly affect property values near the Copper World project were it to open?

The communities that are adjacent to the proposed mine are Sahuarita, Green Valley, Corona de Tucson, and Vail. Sahuarita has a population of 35,638 with 11,382 households,[188] Green Valley has a population of 22,616, with 12,847 households,[189] Corona de Tucson has a population of 9,240 with 2,974 households,[190] and Vail has a

[185] Kim, H. and Harris, D. Air Quality and View Degradations due to Copper Mining and Milling: Preliminary Analysis and Cost Estimates for Green Valley, Arizona. Nonrenewable Resources. Vol. 5, No.2. 1996. Page 100-101.
[186] Census. H085: Median Value (Dollars) For All Owner Occupied Housing Units. 2000: DEC Summary File 3. Accessed 6.29.2023.
https://data.census.gov/table?q=green+valley+AZ+median+value+owner+occupied+2000&tid=DECENNIALSF32000.H085
[187] Census. Green Valley CDP, Arizona. Quick Facts. Accessed 6.24.2023.
https://www.census.gov/quickfacts/fact/table/greenvalleycdparizona/HSG495221
[188] Census. Sahuarita town, Arizona. Quick Facts. 7.1.2022.
https://www.census.gov/quickfacts/fact/table/sahuaritatownarizona/PST045222
[189] Census. Green Valley CDP, Arizona. 4.1.2020.
https://www.census.gov/quickfacts/fact/table/greenvalleycdparizona/INC110221
[190] Census. Carona de Tucson, CDP, Arizona. Quick Facts. 4.1.2020.
https://www.census.gov/quickfacts/coronadetucsoncdparizona

population of 13,604 with 4,992 households.[191] For convenience, we will call these "Copper World communities."

People living in these communities will see a degraded viewscape, which Kim found to decrease home values in Green Valley. Although some communities will be separated from the mine by the Santa Rita Experimental Range, landscape scars and tailings piles will be visible for many tens of miles.[192] According to the PFS, Tailing Storage Facility 1 (TSF-1), on its own, will be approximately three miles in length, one mile wide, and 600 feet tall, taller than the Washington Monument.[193,194]

The waste rock facility will likely be larger and possibly more visible.[195]

Although multiple active and closed mines are located near the Copper World project, this should not be interpreted to mean that adding another mine will have trivial economic costs. The work by Williams,[196] referenced above, found that counties with more open pit mines had much lower property values than those with only one.

Using viewscape and air quality impairments estimated by Kim[197] and escalating the values to 2022 dollars, each household in the Copper World communities would have a cost of $9,871 due to viewscape impairment, and $25,663 due to air quality impairment. These costs are a *decrease* in the value of the homes in this area. Assuming that all of the households are equally affected, the cost of a degraded viewscape is more than $300 million, and the cost of the degradation of air quality is $1.1 billion (see Table 3.).

[191] Census. Vail CDP, Arizona. 4.1.2020. https://www.census.gov/quickfacts/fact/table/vailcdparizona/PST120222

[192] The view from the top of the Gateway arch allows a view of more than "30 miles in either direction." Gateway Arch Park Foundation. The view from the top of the iconic Gateway Arch now visible from anywhere in the world. 5.21.2020. Accessed 10.13.2023. https://www.archpark.org/updates/blog/the-view-from-the-top-of-the-iconic-gateway-arch-now-visible-from-anywhere-in-the-world#:~:text=The%20View%20from%20the%20Top,from%20Anywhere%20in%20the%20World&text=ST.,and%20County%20to%20the%20West.

[193] National Parks Service. Gateway Arch: How Tall is it? Accessed 10.13.2023. https://www.nps.gov/jeff/planyourvisit/arch-height.htm

[194] The view from the top of the Gateway arch allows a view of more than "30 miles in either direction." Gateway Arch Park Foundation. The view from the top of the iconic Gateway Arch now visible from anywhere in the world. 5.21.2020. Accessed 10.13.2023. https://www.archpark.org/updates/blog/the-view-from-the-top-of-the-iconic-gateway-arch-now-visible-from-anywhere-in-the-world#:~:text=The%20View%20from%20the%20Top,from%20Anywhere%20in%20the%20World&text=ST.,and%20County%20to%20the%20West.

[195] Hudbay. NI 43-101 Technical Report Phase I Pre-Feasibility Study and Updated Miner Resource Estimates. Copper World Project Pima County, Arizona, USA. 7.1.2023. Page 16-22 Figure 16-19 and table 16-7.

[196] Williams, A. The Impact of Surface Mining on Residential Property Values: A Hedonic Price Analysis. University of Tennessee-Knoxville. May 2011.

[197] Kim, H. and Harris, D. Air Quality and View Degradations due to Copper Mining and Milling: Preliminary Analysis and Cost Estimates for Green Valley, Arizona. Nonrenewable Resources. Vol. 5, No.2. 1996. Page 100-101.

If we project Kim's values onto only the community of Corona de Tucson, which is the community immediately adjacent to the Copper World site, the combined effects of air quality and viewscape degradation would be $105.68 million.

We get similar results by applying Rivera's findings to the collective Copper World communities.[198] Rivera found that there was an 18 to 26% drop in the cost of rent/value of property when a conventional metal mine moved into the area (the proposed Copper World project falls into this "conventional metal mine" category). Applying the median property value for each of the Copper World communities, the number of homes in each community, and then applying the 18 to 26% loss, the Copper World project would drive aggregate property values down between $1.36 to $1.97 billion (see Table 3.).

Yet another approach to valuing the property value cost is to adopt the 0.34 to 1.7% drop in property value per coal mine within a county reported by Williams. Applying a 0.34 to 1.7% drop to Pima County yields countywide costs of between $355 million and $1.7 billion (see Table 3.).

In summary, the impact that the mine will have on property values, in all of the metrics used in the above studies, would more than offset the direct and secondary benefits of the 3,430 total jobs (direct and indirect) that Hudbay is promising.

Some readers may be skeptical of the size of these projected economic costs. However, we know for certain that one widely-used quantitatively-specific mine damage cost estimate is wrong, and it is the one that is being presented by Hudbay, namely zero. The literature clearly shows that there are substantial drops in housing values when mines open.[199] Here we have used the best available analogous peer-reviewed science so that local residents and decision makers can have an idea of the magnitude of costs they could face if Hudbay's mine opens.

Job offsets

If we provisionally accept Kim's combined viewscape and air quality impairment costs of nearly $1.5 billion, these costs outweigh the benefits of annual wages paid by the mine ($222 million) by a little more than 6 to 1. If we base our calculations on the $1.36 to $1.97 billion costs we calculated above based on Rivera,[200] then costs would

[198] Rivera, N. Is Mining an Environmental Disamenity? Evidence from Resource Extraction Site Openings. Department of Economics Working Papers WP 2019-05. University of Alaska Anchorage.
[199]A 2020 review article found almost a thousand (968) refereed journal articles that applied the tools of Environmental Economics to study the non-market costs associated with mining. The articles were screened for, among other criteria, timeliness, including only papers published during the 40-year period 1980-2020 and published in a recognized referred journal that publishes articles on mining and Environmental Economics. Menegaki, D., and Damingos, D. A systematic review of the use of environmental economics in the mining industry use of environmental economics in the mining industry. *Journal of Sustainable Mining:* Vol. 19: Iss. 4, Article 5. 2020**.**
[200] Rivera, N. Is Mining an Environmental Disamenity? Evidence from Resource Extraction Site Openings. Department of Economics Working Papers WP 2019-05. University of Alaska Anchorage.

outweigh the benefits a little more than 8 to 1 on the high side and about 6 to 1 on the low side. Using the much more modest countywide declines in property values we calculated based on Williams,[201] costs would outweigh benefits about 8 to 1 on the high side and 1.6 to 1 on the low side. Whether using metrics based on Kim, Rivera, or Williams, the decrease in home values would more than offset the direct and secondary economic benefits of the 3,430 total jobs (direct and indirect) that Hudbay is promising.

Table 3.

	Cost
Kim	
Viewscape	$ 317,782,406
Ar Quaility	$ 1,144,016,663
Combined	$ 1,461,799,069
Rivera	
High (26%)	$1,965,505,464
Low (18%)	$1,360,734,552
Williams	
High (1.7%)	$1,775,144,087
Low (0.34%)	$355,028,817

Source: Internal calculations based on the cited authors' methodology.

Table 3. shows the potential economic impacts of mining on the local areas. Kim studied viewscape and air quality impacts on property values, Rivera examined property value declines in the presence of a mine, and Williams analyzed county wide impacts of open pit coal mines.

5. Population growth and in-migration offsets of mine jobs

a. Population growth in Pima County

From 2000 to 2021, Pima County saw a 24% growth in population, substantially more than the national average,[202] "and only 23% of this was due to natural" growth, i.e.,

[201] Williams, A. The Impact of Surface Mining on Residential Property Values: A Hedonic Price Analysis. University of Tennessee-Knoxville. May 2011.
[202] Headwater Economics. Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 15.

births minus deaths. In-migration contributed the other 78%,[203] with more than 5,000 people per year moving to the county.

The cohort of people over 65 years old is growing at the fastest rate, and the under-18 group actually decreased from 2000 to 2021.[204] Because so many older people are moving here with substantial amounts of accumulated wealth, for example retirement funds, per capita income is growing at a much faster rate than average wage compensation.[205] In fact, Pima County has a much higher percentage of non-labor income (almost 50%) compared to the nation as a whole (about 40%).[206] Because these newcomers need homes, during the same 2000 to 2010 period Pima County's residential acreage increased twice as fast as the national average.[207]

Clearly the greater Tucson area offers amenities that are attracting large numbers of people who could live anywhere because they are not dependent on local jobs, either because they have non-labor income, remote work, or both. Our belief that the area attracts and holds people because of amenities is further substantiated by the fact that the largest sector of the economy, "services", pays about $20,000 less annually than the national average wage.[208] This suggests that people are willing to move to and stay in Pima County for the amenities even though they may earn less than in some other places.

One element of this attraction is that Pima County has more federal public land and federal protected land that qualifies as "type A" protected land than does the U.S. as a whole.[209] Headwater Economics describes the value of such public lands this way:

> "When a location has a high proportion of public lands, and when many of these lands are designated as wilderness, national park, and national monument (Type A), then it is likely that the level of environmental and recreation amenities is high. When a location also has a high rate of population growth due largely to in-migration, combined with a conversion of lands for residential development and a high proportion of second homes, then it is likely that amenity-driven growth is taking place. In addition, when the economy has a high rate of growth in service industry jobs, travel- and

[203] Headwater Economics. Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 2.
[204] Headwater Economics. Demographics: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 3.
[205] Headwater Economics. Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 3.
[206] Headwater Economics. Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 15.
[207] Headwater Economics. Living Near Public Lands: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 9.
[208] Headwater Economics. Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 15.
[209] Headwater Economics. Living Near Public Lands: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 9.

tourism-related sectors, and non-labor income, then amenities are likely to play a role in economic development."[210]

This quote aptly describes the Pima County amenities that are attracting so many people. If the mine degrades some of these high-quality natural landscapes, it would undermine the area's economic vitality by discouraging visitors and potential residents.

b. Changes in in-migration and out-migration

We present data in Sections II.2 and II.3 that show how the presence of mining typically causes net decreases in economic productivity and how communities with mines have less economic vitality than communities without them. A major reason is that people perceive a place with environmental degradation as a less attractive place to live.

Based on this information, we predict that relatively small drops in the rate at which people move to Pima County (in-migration) or increases in the rate at which they leave (out-migration) could cause economic losses much greater than benefits from the mine's job creation and property tax payments.

Given that the mine's activities could decrease in-migration or increase out-migration, how big a change would be needed to offset the number of permanent jobs the mine says it will create?

Current levels of in-migration

On average, 6,398 people move to Pima County every year. If people keep moving in at the same rate over the 20-year life of the mine the number of new people arriving would be nearly 128,000. This is 37 times the number of direct and secondary jobs that Hudbay says it would create.

Net changes in migration that would offset Hudbay's projected 430 direct and 3,000 secondary jobs.

- All 3,340 of Hudbay's direct and secondary jobs would be offset if only 2.7% of the 128,000 people expected to migrate in during the 20-year lifetime of the mine chose not to come because the mine had decreased perceived quality of life.
- All 3,340 of Hudbay's direct and secondary jobs would be offset if only 1 out of 268 people (0.37%) in Pima County currently left because of the mine.

Net changes in migration that would offset Hudbay's projected *income* from 430 direct and 3,000 secondary jobs.

- **Non-labor income.**

[210] Headwater Economics. Living Near Public Lands: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 9.

In 2021, non-labor income in Pima County was about $30 billion, roughly 50% of all income.[211] See Section 1.2 for an overview of the contribution of non-labor income to Pima County.

Of course, all people will not have non-labor income, but for the purposes of making a rough calculation, we can average the amount of non-labor income ($30 billion) across the entire population of Pima County. If we assume that each person who migrates out will take with them their per capita share of the $30 billion, the loss of 1 out of every 134 residents (0.745%) residents would completely offset the 3,430 direct and secondary jobs the mine projects to create.

Of course, many people may have both non-labor income and labor income, or only one or the other. We discuss labor income lost to Pima County in the next paragraph.

Labor income

Here we calculate what *labor income* (instead of non-labor income) would be lost when someone migrates out of Pima County. Decreases in labor-income would occur when:

- Distance workers leave and take their labor income with them.
- Workers leave who have locally-based jobs, like restaurant or government workers, and these jobs are not filled by unemployed workers, resulting in a loss of income within the county. Specialized jobs may be more likely to remain vacant.

Because roughly half Pima County income is from labor, we assume that each person migrating out results in a loss of their share of the county total of roughly $30 billion in *labor* income. Therefore, the income lost to the county when someone migrates out would have approximately the same effect as the lost non-labor income, i.e., the loss of 1 out of every 134 residents (0.745%) would completely offset the 3,430 direct and secondary jobs the mine projects to create.

Non-labor income plus labor income

Adding together the loss from both non-labor and labor when, when 1 out of 268 residents (0.37%) migrates out of the county, it would offset all 3,430 jobs that Hudbay claims it would provide for total income.

Considering direct jobs only

[211] Headwater Economics. Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023. Tab 4.

We have done the preceding calculations by provisionally accepting Hudbay's estimate that it will create 3,430 jobs, including 3,000 secondary jobs. However, in Section IV.3d we present reasons why Hudbay's estimate of secondary jobs is unrealistically high. Therefore, rather than only accept Hudbay's estimate in calculating job offsets, we can instead provide a range bounded by the best-case scenario for Hudbay (3,000 secondary jobs), and the worst-case scenario (0 jobs), knowing that the correct value likely falls between. A potential fix for this is that Hudbay shows their modeling work and allows everyone to see where these jobs will be created and why their multipliers are so high. Because this has not been done, we will present the direct jobs as well as the secondary jobs. If the mine goes forward, then we have no reason to doubt the direct jobs that they project, so that is the lower bound for job creation. Since we have very good reason to doubt the secondary jobs, the upper bound would be the direct and secondary jobs added together.

If we redo the above calculations limited to only the 430 direct jobs, the numbers are:

- Income from the 430 direct mining jobs equals 0.143% of non-labor, and 1 person out of each 698 people leaving Pima County would offset these mining jobs.
- Income from the 430 direct mining jobs equals 0.072% of total Pima County income, meaning that 1 person out of each 698 people leaving Pima County would offset the mining jobs.

c. The service industry

The service industry, notably outdoor recreation and tourism, would be directly diminished by damage the mine does to the natural landscape. A decrease in these service industries could in turn contribute to a decrease in in-migration, in turn further decreasing the demand for some service industries, e.g., food and accommodations. Relatively small decreases in the total number of service-related jobs could easily offset the number of jobs added by the mine. If 1 job in 894 (0.1%) of the service-related jobs is lost, then the direct jobs associated with the proposed mine will be offset. If 1 in 112 (0.9%) jobs are lost from the service-related sector in Pima County, then all of the direct and secondary jobs from the proposed mine would be off-set (see Table 5.).

Table 5.

	Income	% of Non-Labor Income	Employment	% of Service Industry Employment
Non-Labor	$29,742,168,000	100%	NA	NA
Direct Mining	$42,631,490	0.143%	430	0.112%
Total Mining	$221,503,490	0.745%	3,430	0.892%
Service Industry	$20,724,770,000	70%	384,456	100%

Source: Headwater Economics. Socioeconomic Trends: Pima County, AZ. Economic Profile System. 6.29.2023 and Hudbay. Hudbay. NI 43-101 Technical Report. Phase I Pre-Feasibility Study and Updated Mineral Resource Estimates. Copper World Project. 7.1.2023.

Table 5. shows the non-labor, direct mining, total mining, and service industry income, employment, and the relative size of the projected mining jobs when compared to both non-labor income and the service industry. Here NA stands for "not applicable".

VI. Making a rational economic decision

If the people living in the Greater Tucson Area believe that economic and quality-of-life costs due to the mine are larger than the economic benefits, then the rational economic decision would be to oppose Hudbay's Copper World project.

Factors to weigh include the economic costs and benefits presented in this report and listed below. The data suggests that the mine would directly damage some service industries, including outdoor recreation and tourism, and reduce the perceived quality of life for residents and visitors, for example by adding heavy truck traffic and wind-blown dust. Although the mine has not made public information that would allow us to quantify such harm to local industries, we conclude that very small percentage decreases in in-migration and service industries triggered by the mine would more than offset the mine's direct and secondary employment. If the mine is not built, the area's economy could lose what Hudbay estimates to be 3,430 jobs, but these jobs are a very small percentage of the area's total employment, and they are swamped by the more than 6,000 people who move to Pima County every year in the absence of the mine.

Another important factor to consider is the time frame. If the mine production ends 20 years after the start of Phase I described in the PFS, benefits to the local economy would also end. But substantial costs to the service industry, the housing market, in-migration, and possibly human health caused by the mine's environmental degradation would likely be perpetual.

This report should inform and empower residents of the Greater Tucson Area to make rational economic decisions about whether greatly expanded mining would benefit or harm their collective well-being. Their considerations should include:

Benefits

1. 430 direct jobs and up to 3,000 secondary jobs.
2. Property taxes to Pima County and income taxes to state and federal government.

Costs

1. The greater Tucson area has a vibrant economy that has done an exceptional job at growing despite national recessions. Much of this growth and resiliency can be attributed to a beautiful natural environment that supports tourism and outdoor recreation that would be damaged by the mine.
2. In Arizona and elsewhere in the U.S., economies in areas without mining significantly outperform economies with mining (Section II.2).
3. The mine would degrade views by removing tops of some Santa Rita mountains, digging immense pits, and building tailings piles with hundreds of millions of tons of potentially toxic tailings.
4. By making the area less attractive to live in, the mine would likely increase out-migration and decrease in-migration. Currently, more than 6,000 people per year choose to move to the greater Tucson area. This is slightly less than double the total number of direct and secondary jobs Hudbay claims it will create. (Section IV.3c).
5. Total jobs generated by the mine would add to the economy only about 0.37% of total personal income currently generated from other economic sectors. (Section IV.3c)
6. Mining would diminish service industries, including recreation and tourism. A drop of only (0.9% in the service industries would offset all direct and secondary jobs projected by Hudbay. (Section V.5c)
7. If only 0.745% of Pima County's current residents leave the county because of the mine, this would offset all the mine's projected direct and secondary jobs. (Section V.5b)
8. The mine would depress collective property values in Pima County, likely between several hundred million dollars and more than 1 billion dollars. (Section V.4)
9. It is likely that during the first four years Hudbay will use in the neighborhood of 6,000 acre-feet (2 billion gallons) per year, rising to at least 13,000 acre-feet per year if and when the leach facility is built. This enormous use would likely make it more difficult for other users to get the water they need.
10. Phase I would involve 100 or more trips by heavy trucks every day passing through the Santa Rita E Range and by the Sahuarita Highlands residential area. If Phase II is developed this might entail using an additional route along scenic SR 83 as described in the 2022 PEA.

11. Pima County residents and decision makers should consider the cumulative effects of all possible future mines that collectively decrease quality of life in the greater Tucson area.

Conclusions

1. The greater Tucson area has a diverse and robust economy that is supported by rapidly growing service-sector industries, high tech manufacturing, and the natural and cultural amenities of the local area. The local area has weathered a series of national recessions with resilience and has established itself as an outdoor recreation destination. People who live in and move to the greater Tucson area have much higher levels of non-labor income, which suggests that they have chosen the area over many other potential locations for their residential resettlement.

2. Pima County has been very purposeful in its acquisition of open space and public lands paid for through bonds issues approved by the local residents. It is because of this purposeful protection and stewardship of natural amenities that Pima County has seen a host of economic indicators, like population and in-migration show better than average growth.

3. There was a time when the economies of Arizona and the greater Tucson area may have been dependent on an economic base, of which mining was an important part. While mining may offer relatively high pay per job, mining has been shrinking as a component of the overall Arizona and greater Tucson economies, while the service-related industries have grown significantly. The potential for environmental degradation associated with the proposed mine, the persistently poor economic performance of mining areas compared to non-mining area in the state and nationally, and the importance of the in-migration of new residents and businesses attracted by Arizona's abundant natural amenities, provides a warning about the potential conflict between protecting those natural amenities that support economic vitality and embracing a new wave of metal mining and ore processing.

4. The potential for as many as 3,430 mine-related jobs (direct and secondary) should be carefully weighed against the fact that over the 20-year life of the proposed Copper World/Rosemont Mine Complex there will be large fluctuations in the copper market. According to the PFS, if the market price for copper drops below $3.75 per pound, it may not be economical for the mine to continue production. In this case workers may be idled and income taxes not paid. Ultimately, the mineral resource will be depleted and the site abandoned. Although the mining jobs will not be perpetual, the

environmental degradation and resulting decreases in service-industry jobs will be.

5. The USGS designates *minerals* that are critical, and that designation allows tax incentives to be given by the federal government through vehicles like the Inflation Reduction Act. Although the DOE has designated its own list of *materials* critical for energy development, it is unknown if these materials will qualify for tax incentives. Copper, based on the DOE's own analysis, is not critical in the two timeframes they analyzed, namely short-term and medium-term. For the first four years that the mine will operate, Hudbay plans to ship concentrate into the world market, which will not qualify it to receive tax incentives. Even *if* Hudbay builds a cathode processing facility on-site, more than 40% of its concentrates will still be shipped into the world market. This contradicts the 'made in America' label that Hudbay has been promoting.

6. The new mining jobs that Hudbay's proposes to create for its Copper World/Rosemont Mine Complex represent fractions of 1% of the total jobs in the greater Tucson area economy. Compared to these benefits, the mine has the potential to cost the greater Tucson area far more by decreasing service-sector jobs, lowering property values, monopolizing water supplies, increasing health care costs, and decreasing in-migration. Most of the value created by the mine will flow to the state, the federal government, and to the Canadian mining firm and its stockholders.

7. Arizona and the other Lower Colorado River Basin states are now in the driest period of the last 2,000 years and perhaps 6,000 years or more. The Colorado River Compact, which delivers millions of acre-feet of CAP water to Arizona, is already unable to deliver the water allocated to all users, and the Biden administration has put in place a short-term agreement that is paying over a billion dollars to Native American tribes, farmers and other water users to *not* use their allocated water.

   In this water starved west, Hudbay would like to use the same amount of water as 50,000 to 119,000 people. The market value of the water that Hudbay will receive for free is about $1 million to $7 million per year.

   Because Hudbay will pump such massive amounts of water, towns like Sahuarita will see their ability to pump groundwater severely curtailed for hundreds of years. Hudbay's use of this volume of water necessarily means that other water users, like municipalities and farmers, will not be able to use all of the water to which they previously had access. That will fundamentally change the water-use patterns in Arizona as well as the character of the economy and society.

8. By releasing dust, impairing the viewscape, decreasing recreation opportunities and in other ways damaging amenities that play major roles in the greater Tucson economy, Hudbay will cause property values in the greater Tucson area to drop. Estimates of the damage to property values range from $355 million to just shy of $2 billion. Drops in residential real estate value will likely be several times greater than economic value from mining jobs.

9. The health of the outdoor industry is dependent on open space and access to protected public lands. Small impacts to the outdoor industry because of the proposed mine can have ripple effects that are felt throughout the greater Tucson economy. The interdependence of the outdoor industry, the quality-of-life for local people, and the ability of the local area to attract in-migrants is critical to understanding and protecting the local economy. People are living in and moving to the greater Tucson area with large amounts of non-labor income. On average, if 0.072% (one in 1,395) of people that live in Pima County, were to leave or not locate there because of the proposed mine, the direct wages projected to be associated with the Copper World Complex/Rosemont Mine Complex could be offset by this small exodus.

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Since the world's increased copper demand can be covered with existing supplies and technology, the U.S. should carefully scrutinize any new copper mine until the 1872 Mining Law, which is notoriously out of date, can be reconnoitered to protect the people around the mines, the land, and help streamline the permitting process. Without this systemic change, copper mines in the U.S. run a very real risk of repeating what Madrones found in Chile[212]: that copper mines, while they may produce vast amounts of wealth, ultimately provide little to no positive impacts for the local areas that they reside in. Fixing the 1872 mining law is something that the Biden Administration has taken a keen interest in and is a reform that should be seriously considered.[213]

[212] Please see section II.3 above.
[213]The Whitehouse. Readout of the White House's First Stakeholder Convening on Mining Reform. 5.11.2022. Accessed 6.14.2023. https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/11/readout-of-the-white-houses-first-stakeholder-convening-on-mining-reform/