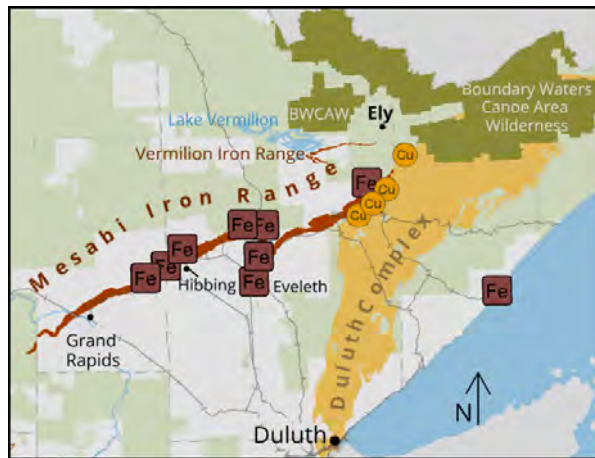


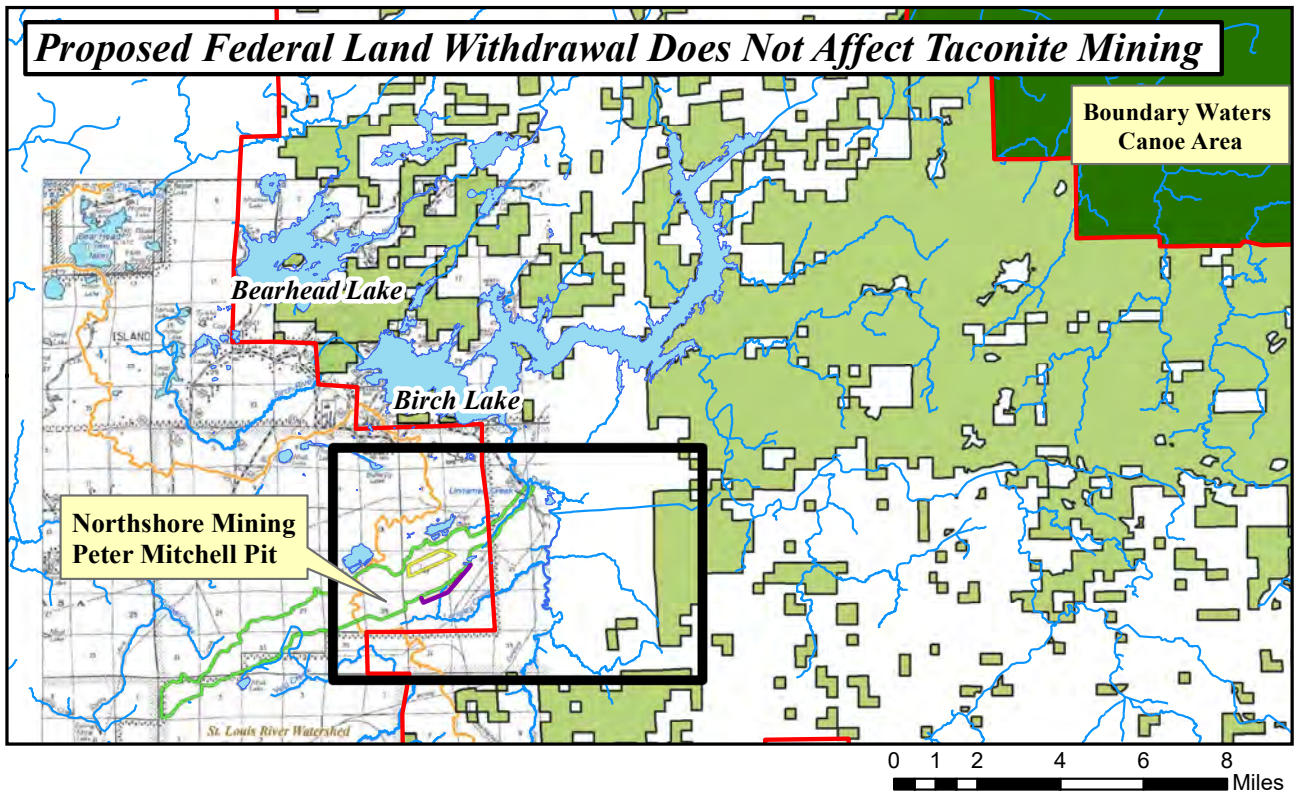
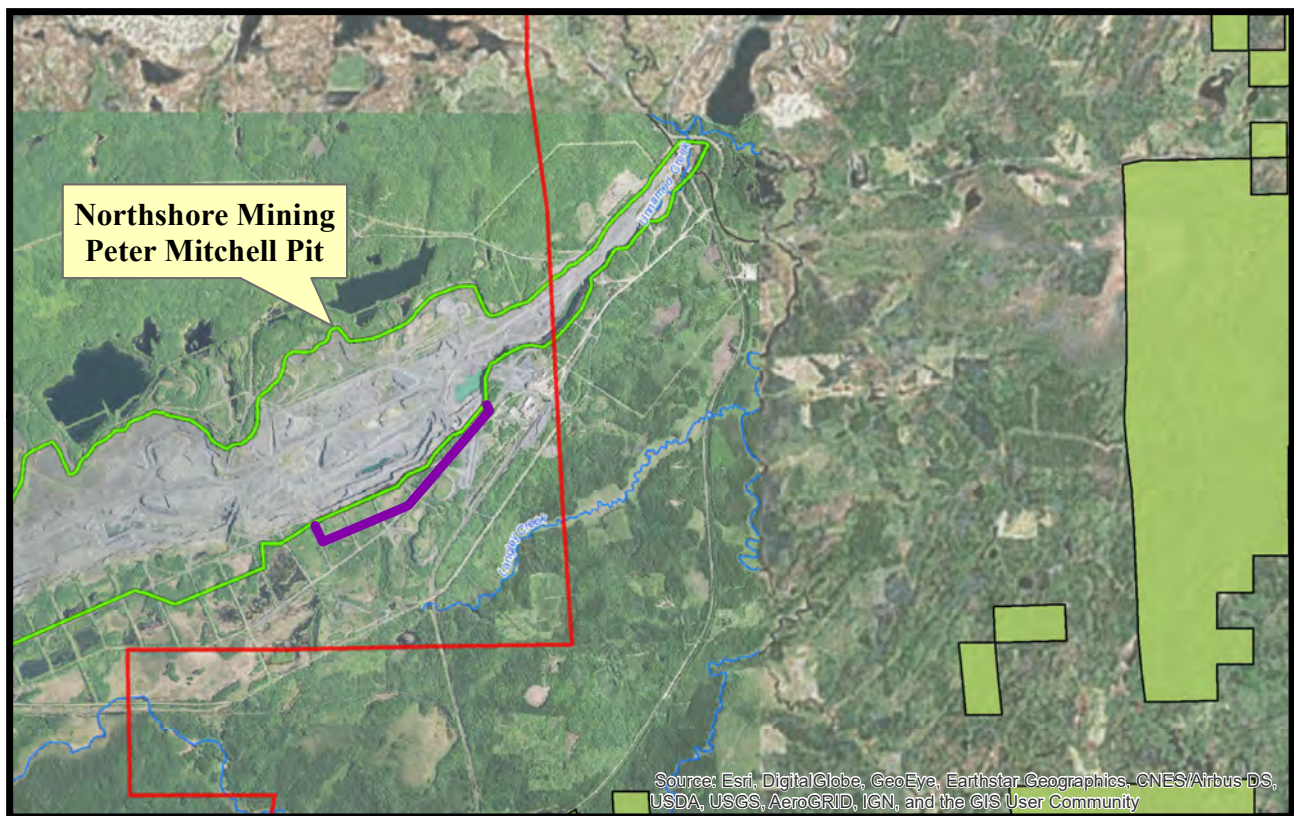


Proposed Federal Land Withdrawal Does Not Affect Taconite Mining

- The proposed 20-year moratorium on new sulfide-ore copper prospecting/leasing/mining on federal lands within the BWCAW watershed does **not affect any taconite mining operations**.
- Taconite (iron ore) and sulfide-ore copper deposits are found in **different places and different rocks**.
- The sulfide-ore copper deposits come into contact with taconite at only one location, at the far eastern end of the Mesabi Iron Range. A planned mine expansion there **is not obstructed** by the proposed 20-year withdrawal (see map on flip side).
- The Withdrawal is proposed for federal lands within the BWCAW watershed because **sulfide-ore produces acid and releases heavy metals** when exposed to water and oxygen. This acidic, heavy metal pollution is especially toxic to fish and other aquatic life, and poses a health threat to people.
- Sulfide-ore copper mines have a **100% track record of polluting** surrounding surface and ground water with toxic heavy metal and acidic pollution.
- The US Forest Service determined that the water-rich, Wilderness edge environment of the BWCAW **is the wrong place for the inherent risks** associated with sulfide-ore copper mining.



Taconite (iron ore) mines and plants denoted by "Fe." Copper deposits and proposed projects denoted by "Cu." Map modified from MN DNR "Minnesota Minerals" 2016.



N Legend



— Pit Boundary-- Current

— Pit Boundary-- Proposed

— Federal Land Withdrawal Application Boundary

■ BWCA

■ Federal Lands Proposed for Withdrawal from Sulfide-Ore Copper Mining



Created by: Abigail Miranda, July 2017
Data Sources: US Forest Service, MN Department of Natural Resources, ESRI

**A Review of
“The economic impact of ferrous and non-ferrous mining on the State of
Minnesota and the Arrowhead Region”¹**

Evan Hjerpe, Ph.D.[†] and Spencer Phillips, Ph.D.[‡]

December 30, 2013

Brief Summary: Regional economic impact analyses can be helpful in illustrating potential changes in output, income, and employment that might result from new development. Economic impact analysis (EIA) is, however, subject to stringent methods that must be adhered to in order to provide credible estimates of impacts. Additionally, EIA is based on an underlying set of restrictive technical assumptions that may apply only in rare instances. Thus, great care must be taken in conducting and using the results of economic analysis if it is to have any value at all. The proliferation of turn-key economic impact models, such as IMPLAN, has made it extremely easy to produce estimates of economic impacts by non-economists or economists with little training in this area. Impacts can be generated with little consideration for the underlying methods and technical assumptions. This has resulted in a wide range of quality in economic impact analyses.

After examining “The economic impact of ferrous and non-ferrous mining on the State of Minnesota and the Arrowhead Region, including Douglas County, Wisconsin,” (hereafter “the UMD report”) we conclude that the University of Minnesota, Duluth’s economic impact analysis falls squarely at the “low-quality” end of the spectrum. In brief (and as detailed below), the reasons for this conclusion include the following:

- The authors of the UMD report failed to adhere to a number of the most critical EIA methods. Multiple violations of standard EIA methodology undermine all generated IMPLAN results.
- The underlying technical assumptions of input-output modeling, the core tenet of IMPLAN, lead to an unrealistic picture of the regional economy, because they inflate induced effects and multiplier effects. As such, researchers generally take a deliberately conservative approach and/or perform sensitivity analysis. The UMD report incorporates neither.
- The authors of the UMD report provide no comparison of potential mining multiplier effects to multipliers for other industries within the regional economy. Without comparison, the reader has no context with which to judge the impacts.

¹ Skurla, James A. et al., *The Economic Impact of Ferrous and Non-Ferrous Mining on the State of Minnesota and the Arrowhead Region, Including Douglas County, Wisconsin* (University of Minnesota, Duluth: Labovitz School of Business and Economics, November 2012), <http://www.d.umn.edu/lbsbe/bber.php>.

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- The authors do not acknowledge the limited role and application that EIA results have in the overall environmental assessment of mining impacts. Apart from a brief note in Appendix B that “a detailed cost-benefit analysis is beyond the scope of this report,” the UMD study does nothing to place the modeled (short-term) economic impacts in the context of what are reported elsewhere to be significant, long- and short-term negative environmental, economic and fiscal impacts of non-ferrous mining in Northeast Minnesota.²

1. Introduction

New, non-ferrous mines are being proposed in northeastern Minnesota, but need to undergo an environmental planning process to help determine if the new mines are in the public interest of Minnesotans. The primary component of determining public interest is assessing the overall environmental impacts of proposed projects to determine if the public benefits outweigh the public costs. Part of this process has also typically included an assessment of potential economic impacts that might be generated by the proposed mining. A recent study, “Economic Impacts of Ferrous and Non-Ferrous Mining on the State of Minnesota and the Arrowhead Region, and Douglas County, Wisconsin,” was conducted by The Labovitz School of Business and Economics at the University of Minnesota Duluth (hereafter, “UMD report”). In this paper, we review UMD’s economic impact analysis, so as to provide an objective perspective on the associated economic impacts of proposed mining expansion, with particular attention to new non-ferrous mining. Because proposed non-ferrous (sulfide) mining is new to the region and has the greatest environmental impact, we review the report with an eye on the implications for non-ferrous mining.

The UMD report suffers from multiple technical and methodological flaws and does not address any associated costs of non-ferrous mining. These flaws include: inappropriate study area delineation, a lack of rigor in data collection, and inappropriate inclusion of past economic activities related to existing mining production. Additional problems, and technical errors, were also found throughout the report that led to consistently inflated economic impacts. The presented economic impacts are therefore not credible estimates and require an entirely new analysis to correct these fatal flaws.

2. Economic Impact Analysis (EIA) and Environmental Planning

To provide greater understanding of the role of the UMD report, it is helpful to first frame the scope of EIA in terms of its value in determining overall public costs and benefits. In the broad picture of net public interest, EIA is narrowly focused on short-term changes in regional economic indicators. As such, EIA does not shed light on any associated costs to society that might result from the proposed

² Marcotty, Josephine, “Iron Range Mine Could Pollute Water for up to 500 Years,” accessed December 3, 2013, <http://www.startribune.com/local/226548091.html>; Dunbar, Elizabeth, “State’s Top Elected Officials Approve Mineral Leases, with Reservations,” *MPR News*, accessed November 25, 2013, <http://minnesota.publicradio.org/display/web/2013/10/25/elected-officials-vote-on-mineral-leases>.

development (e.g., environmental impacts, damages to other industries, or long-term viability of the industry or the region). Furthermore, economic impacts, even if positive, are rarely considered as economic benefits for the regional economy.³ This is because regional economies are dynamic, but gravitate towards equilibrium in terms of economic indicators. That is, losses in one sector of the economy are generally offset by gains in other sectors; and gains in one sector are generally offset by losses in others, despite the tendency for regional economies to attain overall growth or restriction in the long run.⁴

Thus, the results of economic impact studies provide only a portion of the overall economic effects associated with proposed development, for a very limited amount of time, and virtually none of the overall societal costs and benefits over time. This is important to consider when exploring regional economic development strategies.

Another consideration for the scope of economic impacts is that most are presented in isolation. While generated multipliers and impacts may appear large or small, the public and decision-makers have no context for the results if they are not compared to multipliers and impacts from other industries for a similar regional economy. What do these numbers mean? Depending on geographic, demographic, and other variables, regional economies and individual entrepreneurs have choices in the form of economic development they would like to pursue. Without a comparison to the impacts and multipliers associated with other types of industrial development in a particular region, the public and decision-makers do not have a proper context for framing results.

3. Disregard for Critical Economic Impact Analysis (EIA) Methods

We present the most critical EIA methods in detail below to provide the reader with their importance in determining all the subsequent results and economic impacts provided by models such as IMPLAN. Failure to adhere to these methods produces unreliable and inaccurate estimates of economic impacts, often leading to double, triple, and quadruple counting of unique economic impacts of income, employment, or industry purchases.

3.1 Defining initial changes in final demand

The driver of economic impact analysis is the *change in final demand* (via output, value-added, or employment) in the defined region that will be spurred by a new development. This change in final demand, or “shock” to the regional economy, is estimated by the researcher based on surveys of businesses and individuals, or in the case of the UMD report, getting input from mining companies and other groups to ascertain “employment estimates, local purchases, and operations dollar value of sales or output production (p. 3).” The change in final demand is entered into IMPLAN software and applied

³ Consumer surplus is the appropriate measure for economic benefits.

⁴ These economic trends are perhaps easiest to understand from the individual laborer perspective. Regional economies typically have a limited labor supply. When an individual loses their job, they typically seek and find work at another company, as opposed to staying unemployed and representing a permanent loss to the economy.

to the predictive I-O model for the particular region being studied. Once changes in final demand are entered into IMPLAN for the affected industry sectors, the software provides the *direct effect* to the region (subsequent analysis options allow for estimating *indirect and induced effects*).

All changes in final demand result in direct effects, but based on regional purchasing coefficients (RPCs) and location quotients as defined by the size and structure of the regional economy, IMPLAN software categorizes these direct effects by industry sector, domestic trade, and foreign trade. That is, direct effects are the initial estimate of how much of the regional final demand changes impact regional industry sectors, how much leaves the defined region as domestic trade, and how much leaves the country as foreign trade.

Critically, data collection for changes in final demand is concerned only with economic activity that occurs in the defined study area. For example, if a mining company owns a mine in one part of the state, has state headquarters in another part of the state, and has international headquarters outside of the U.S., different changes in final demand will occur in all three areas based on new mineral sales. The location and impact of final demand changes based on mineral sales is different for each particular region. Given this, the proper delineation of the study area for regional economic impact analysis, and capturing final demand changes that occur within that region, are critical first steps in determining accurate direct effects and subsequent multiplier effects.

Multipliers represent the amount and number of times economic activity (e.g., output, value added, or employment) re-circulates within the defined study area. Specifically, multipliers are the ratio of total effects (direct + indirect + induced) to direct effects. All economic activity that is not captured by the local economy due to imports and purchases elsewhere is considered leakage. *The size of the defined study is a major determinant of the resulting multiplier effect, with larger study areas capturing more of the economic activity.*

Researchers have illustrated that study areas for regional EIAs should be restricted to the region most affected, not only in terms of economic impacts, but also in terms of costs incurred.⁵ The reasons for this are twofold. First, increasing the study area for localized economic development projects (such as for a few counties) beyond its primary economic influence (e.g., to the state-level) results in inflated multipliers and impacts. Secondly, and perhaps more importantly, an EIA should compare local economic impacts to local costs of such development including the need for greater public services and costs associated with environmental degradation.

As such, changes in final demand are strictly the purchases, sales, and employment that will occur within the study area. On p. 6, the UMD report correctly defines direct effects as *“Initial spending in the study area resulting from the project.”* On the same page, the UMD report also correctly defines value added and output in terms of *“contribution to the local economy”* and *“the value of local production.”* But, throughout the UMD report, two dramatically different study areas are used (the Arrowhead Region and the State of Minnesota), yet the majority of direct effects remain the same for both. This indicates that

⁵ Hjerpe, E.E. and Y. Kim. 2007. Regional economic impacts of Grand Canyon river runners. *Journal of Environmental Management* 85(1): 137-149.

only one set of final demand changes were used for both study areas. This is a fatal flaw that undermines the credibility of the entire report.

- The authors of the UMD report utilize and present results for two different study areas: 1) the Arrowhead Region of Northeast Minnesota, which includes seven adjacent Minnesota counties and one adjacent Wisconsin county; and 2) the entire state of Minnesota, which includes 87 counties. The proposed mining expansion will all occur in the Arrowhead Region, making this the more appropriate study area. The only reason we can see for also utilizing an additional study area of the entire state of Minnesota is to boost reported economic impacts. Indeed the first and primary comprehensive Table provided in the executive summary shows only the inflated impacts resulting in the entire state (p. viii). Utilizing two separate study areas is inappropriate and reflects a poor understanding of economic impact analysis. *If using multiple study areas, each study area must have its own survey (or data collection) of changes in final demand.*
- For these different study areas, most of the reported direct effects are identical. (Compare Tables 4 and 5 (p. 11); Tables 8 and 11 and Tables 9 and 12 (pages 14-15); Tables 18 and 19 (p. 20); Tables 22 and 25 (pp. 22-23); Tables 23 and 26 (pp. 23-24); Tables 33 and 35 (pp. 28-29), and Tables 34 and 36 (pp. 28 and 29). This illustrates that the researchers did not collect economic data specific to each defined study area, but rather utilized one set of final demand changes for both study areas. This is problematic for a number of reasons. First, Douglas County is in Wisconsin, and changes in final demand (and resulting direct effects) for construction, operation and output sales that occur in Wisconsin should not be counted in Minnesota. So even if 100 percent of the direct spending associated with the proposed new mining were to occur in the smaller study region, at least some of that effect would have to accrue to Minnesota's neighbor to the east.

Second, it is extremely unlikely that 100 percent of the direct spending would occur in the Arrowhead region in the first place. At least some of the increase in employment required to support the new and expanded mining would occur in the company's down-state and/or out-of-state / out-of-country offices (i.e., PolyMet state headquarters in St. Paul and international headquarters in Toronto). Wages and salaries earned by managers in the Twin Cities should not be confused with (or counted the same as) wages and salaries earned by mine workers in the Arrowhead region.

Third, it is likely that the sale of ore itself would be transacted in places far from the mine, and large portions of those sale proceeds (e.g., profits) would be part of the direct effect in those distant places, not in the Arrowhead Region. As is often the case with multinational mining companies, only the value-added portions of mineral sales would accrue as economic impacts in the Arrowhead Region.

Without seeing the precise assumptions and numbers that went into the estimation of the initial

changes in final demand, it is not possible to say how much smaller the direct effect in the Arrowhead region should be. One can be certain, however, that those effects would be different, and smaller in the region than in Minnesota as a whole.

Interestingly, there are a couple exceptions in the presented Non-Ferrous Mining direct effects (Tables 22 and 25, and Tables 23 and 26) where only the value-added components are actually slightly different and are carried over to the summary tables in the combined totals at the end of the report. However, the value-added direct effects in these tables are actually higher in the smaller, Region Operations tables. We presume these are typos, as it suggests that value-added impacts that occur in seven Minnesota counties somehow got lost on their way to the State of Minnesota. (The only way this would make sense is if the effects are so much larger in Douglas County, Wisconsin that they overwhelm the difference between Minnesota-wide effects and those occurring in the Minnesota portion of the Arrowhead region. But of course if this is true, then it further calls into question the estimates of direct value-added effects that are identical for the entire Arrowhead region and the entire State of Minnesota. (See, for example, Tables 9 and 11.))

- There is very little detail presented in the UMD report concerning their data collection and their construction of initial changes in final demand, yet this critically determines the direct effects and additional indirect and induced effects. The reader is only told that mining companies and other mining associated groups provided input to the authors to ascertain “employment estimates, local purchases, and operations dollar value of sales or output production (p. 3).” Accuracy and consistency in data collection is the first fundamental step in sound science. How were data collected? Did the author’s provide respondents with a written survey? In-person interviews? What regional economic study area was used? This information should be noted in the text and surveys and data collection instruments should be provided in an appendix.
- Many of the estimated jobs may be filled by transient workers, who will earn wages in the area and spend them elsewhere. It is not clear if this was taken into consideration for the initial estimates of changes in final demand. If not, employment effects will be overestimated for the regional economy.

3.2 Defining economic impacts

EIA, and its technical assumptions, are predicated on forecasting the impacts of *new* changes, or a “shock,” in final demand for a regional economy, most often from a proposed policy change or development plan. Economic impact analysis is defined in the IMPLAN Analysis Guide⁶ as:

“An assessment of change in overall economic activity as a result of *some change* in one or several economic activities [emphasis added].”

⁶ IMPLAN Professional Analysis Guide. 1999. Technical Report. Minnesota IMPLAN Group, Inc.

Despite this, the UMD report includes all *on-going* ferrous and non-ferrous mining operations in the impact study, combined with estimates of new construction and operation. The first summary table in the Executive Summary (p. viii), and likely the most important take home message from the report, claims that the total economic impacts are a “...Value Added total of almost \$5 billion, and Output of almost \$7.8 billion, and an Employment total of more than 27,300 (p. viii).”

Existing operations are supposed to be used to understand the current economic relationships between industry sectors that will be used to estimate potential economic impacts from the “shock” of new final demand changes in that industry. *These impacts have already been absorbed by the regional economy and should therefore not be counted among the impact of the new changes in the economy.* Inclusion of existing operations indicates a lack of understanding economic impact analysis and grossly exaggerates impacts. In reality, such rapid mining expansion would come at the loss of existing mining industry due to increased cost of supply inputs and decreased market prices of final products from flooded local markets.⁷

4. Critiques of I-O Modeling and Implications for the UMD Report

There are numerous technical assumptions required for input-output (I-O) modeling, a core tool of economic impact analysis. I-O modeling is the balancing of all industrial sector sales and purchases, and exogenous sectors such as households,⁸ government, and foreign trade. That is, increases or decreases in one sector will yield a cascading effect on many other sectors that will ultimately balance out. The primary technical assumptions include linearity among production functions, fixed technical coefficients, homogenous sector output, and no supply constraints.⁹ The resulting implications of these assumptions yield a static regional economy, with no economies of scale, no technological advances, and an unlimited supply of resources and labor. In short, this is far from a realistic portrayal of any regional economy, but necessary for the mathematical balancing conducted within I-O models. These assumptions traditionally lead to inflated economic impacts. For example:

- Due to the unrealistic technical assumptions necessary for input-output modeling, all multipliers, and especially employment multipliers, are inflated and should be viewed with extreme caution. For example, the linear production functions lead to the presumption that businesses and households will spend and consume at the same rate. In reality, once a certain threshold in income is achieved, more saving and investing occurs (and often these savings are invested outside the region).

⁷ Stacking new impacts on top of on-going operations also illustrates the problems associated with unrealistic I-O modeling assumptions of linear production functions and unconstrained supply pools.

⁸ Households and other previously exogenous sectors have been “endogenized” in the structural accounting matrices used for most modern multiplier effects, such as in IMPLAN.

⁹ Miller, R.E. and P. Blair. 1985. Input-output analysis: foundations and extensions. New Jersey: Prentice-Hall, Inc.

- Another example comes from the hypothetical economic assumption of fixed technical coefficients. Forecasting mining impacts in the year 2016 neglects improvements in technology. Labor-displacing technology is significant in the mining industry.
- The employment impacts in the UMD report are presented in terms of full and part-time jobs, not Full-Time Equivalents. Because of the seasonal and temporary nature of mining jobs, especially for all construction impacts, the reporting of employment impacts is suspect. The UMD report imparts no information of the typical percentages of seasonal and temporary workers in the mining industry. Without this context, the public and decision-makers are left wondering what the real impact will be. Likewise, the UMD report provides no comparison to potential employment impacts that might result from investments in other forms of economic development. How do these numbers compare to other industries that communities might want to pursue?

Given that the UMD report acknowledges how these assumptions can lead to overestimates, and given that information about the critical relationship between output and employment was provided by mining project managers without additional information taken from independent sources (p. 8), it would be reasonable to expect the UMD report to take a more conservative approach.

5. Tax impacts

The tax impacts from existing and proposed mining in Minnesota are presented in the UMD report in detail. At first glance, they appear impressive. Upon a closer examination, however, it becomes clear that the mining industry is afforded minimal taxation by the State of Minnesota.

- A calculation of overall taxes presented in the UMD report illustrate that the mining industry is afforded an *effective regional tax rate of less than one percent of calculated direct output*.

\$17.6 million in 2010 from Table 38, divided by \$1.85 billion of estimated direct output for both ferrous and non-ferrous 2010 baseline from Table 41 = 0.95%.

As direct output in the region is necessarily smaller than overall sales of final mining products, this effective regional tax rate is miniscule and represents major tax breaks provided to the mining industry. The more important question is how do these tax rates compare to other sectors in the economy? Given the normal regional rates of taxation on most industries (e.g. tourism), a comparison within the UMD report would provide substantial context for the public and decision-makers.

- No costs associated with mining are presented in the UMD report. Yet, we know from recent history that mining is a boom and bust industry, susceptible to volatile, global mineral pricing. We also know this type of development will require increased infrastructure, health, and emergency services that are needed with such rapid development. Additionally, ample public

taxes will be needed in the future to pay for future rehabilitation and reclamation of degraded mining lands, as well as continual monitoring of water quality and active treatment for hundreds of years, at least.¹⁰ With such a miniscule effective tax rate for the mining industry, it seems prudent to question whether current annual taxes can keep up with the public service needs stemming from rapid development, much less provide for future clean-up costs.

But, the less than one percent effective regional tax rate per direct output is not the only exceptional characteristic of Minnesota mining taxation. A deeper look at the collected taxes shows that of 13 tax accounts, six are funneled back into minerals management (Table 38). While we do not know the exact distribution of each tax account,¹¹ the appearance is that a substantial portion of the taxes collected are reinvested back into the mining industry. This represents further tax breaks and kick-backs to the mining industry in Minnesota.

6. Other Problems with the UMD Report

The UMD report is deficient in many areas, leading to consistent inflation of actual economic impacts stemming from mining in the region. Other issues from the UMD report include:

- Table 1 and the discussion on Gross Regional Product (GRP) on page 4 are incorrectly presented, and very misleading. First, GRP is equivalent to a state's gross domestic product (GDP) and represents the market value of *final* goods and services. Including indirect and induced effects in GRP calculations (as noted beneath Table 1) is inaccurate and a poor use of multipliers and leads to substantial overestimates. In fact, intermediate inputs from other industries should be subtracted, not added (see BEA definition for state GDP).¹²

Secondly, the UMD report states that, "Note that the GRP for the State of Minnesota was \$281.1 billion. When compared to the State, mining GRP totals approximately 5.3% for 2010" (p. 4). At 5.3%, mining GRP for Minnesota in 2010 is presented as \$14.9 billion. However, when we looked at the source presented in Table 1 (BEA Regional data), we find that for 2010, mining as a whole represented only \$724 million of Minnesota GDP, or 0.3% of Minnesota GDP for that year

¹⁰ Karnowski, Steve, "New Environmental Review Due for PolyMet's Copper-Nickel Mine," *Associated Press*, accessed December 5, 2013, http://www.twincities.com/localnews/ci_24634015/minnesota-copper-nickel-mine-new-environmental-review.

¹¹ Some taxes may in fact be used to help clean up mine sites. But, the appearance is that a significant portion of mining taxes are spent on increasing mining development (e.g., funding university advocacy).

¹² The BEA defines gross domestic product by state as: "GDP by state is the value added in production by the labor and capital located in a state. GDP for a state is derived as the sum of the gross domestic product by state originating in all industries in a state. In concept, an industry's GDP by state, referred to as its "value added", is equivalent to its gross output (sales or receipts and other operating income, commodity taxes, and inventory change) *minus its intermediate inputs* (consumption of goods and services purchased from other U.S. industries or imported). Thus, GDP by state is the state counterpart of the nation's gross domestic product (GDP), BEA's featured measure of U.S. output." Italics ours.

(\$268.6 billion). It is unclear how the numbers in the UMD report were derived. *This is a major discrepancy and leads to vast inflation of mining's importance.*

- The comparisons to the tourism industry GRP in Table 1 are also misleading, as they vastly under-represent the industrial sectors that combine to make up the tourism industry. The tourism industry is comprised of portions of multiple industries, making it difficult to assign a GRP value. The notes for Table 1, state that tourism was estimated from two IMPLAN sectors, “amusements, gambling, and recreation,” and “accommodation and food services.” This, however, does not capture all tourism products. A number of researchers have illustrated that additional sectors combine to make up the tourism industry.¹³
- The UMD report gathered all necessary inputs from mining companies and mining-associated organizations and agencies. Given that the report was prepared for these same groups, we believe that a more objective approach would include input from other perspectives, particularly those of sectors (industries, households) likely to be harmed by non-ferrous mining in the study region.
- An earlier version of the 2012 UMD report was released by UMD in 2009. The 2009 version appears to suffer from the same methodological failures detailed above. However, one note of interest is the major decrease in economic impact for both existing and proposed non-ferrous mining expansions. The direct employment in the region for non-ferrous on-going operations decreases from 531 in baseline 2007 (in the 2009 UMD report, p. 30) to 175 in baseline 2010 (in the 2012 UMD report, p. 20), or a 67% decline. While we question the accuracy of all estimates in the reports, this is a precipitous decline if taken at face value¹⁴. It is also emblematic of the lack of accuracy in UMD's projected economic impacts. Instead of gaining more than 2,000 direct jobs in the region that were supposed to be operational by 2013 (as projected in the 2009 UMD report, p. 32), the non-ferrous industry has been losing jobs. This issue also highlights the inability of I-O models, such as IMPLAN, to account for changes in production functions and technical coefficients.

7. Conclusion

After thoroughly reviewing the UMD report, we conclude that the study is deficient in a number of areas and suffers from fundamental flaws. We also conclude that even if accurate economic impacts were presented for potential mining expansion, they should be viewed as a small component of the overall

¹³ For example, Marcouiller, D.W. and X. Xia (2008. Distribution of Income from Tourism-Sensitive Employment. *Tourism Economics*. 14(3): 545-565), include those sectors listed as well as portions from the Retail Trade and Passenger Transportation sectors.

¹⁴ We recognize a recession occurred during this time. However, baseline contribution of ferrous mining increased during this period.

costs and benefits to society. The public interest should be most concerned with the long-term consequences of mining development, the costs incurred, and opportunities that will be lost.

Finally, communities in Northeastern Minnesota should be very cautious in pursuing a particular economic development strategy. “If some is good, then more is better,” is not always applicable. To wit, economic diversification increases community resilience in times of recessions and when exposed to the “bust” cycle of an important industry sector. If mining is indeed already 30% of gross regional product in Northeastern Minnesota (p. 4), a virtual doubling of direct mining jobs will render the region utterly dependent on a known boom and bust industry, decreasing its overall economic diversification. This is not a wise economic development strategy.



Watch out, Ely: Mine robots are on the way

Are jobs obsolete? Automation in the industry is coming — and it's sooner than we think.

By Paul and Susan Schurke

OCTOBER 20, 2017 — 6:17PM

Antofagasta, the Chilean owner of the proposed Twin Metals copper mine near the Boundary Waters Canoe Area Wilderness, must take sly pleasure at the tedious backbiting and infighting here in Ely, Minn. It certainly diverts local attention from the tsunami that's hitting the mining workforce around the world.

“Taking the miner out of mining” is a major theme these days among mining industry planners, according to the article “The Robots Are Coming” in the current issue of Mining Magazine, a leading industry journal since 1909.

Industry news is abuzz with breakthroughs in automation and robotics. This is not pie-in-the-sky scheming: Four of Australia's open-pit iron mines, along with an underground mine, are already automated. Robotic excavators dig the ore, driverless trucks move it out of the mine, driverless locomotives take it to processing. Mining giant Rio Tinto, sensing the shock waves this might send through its global workforce, is quick to note that some of the miners have been retrained to monitor this equipment — at a robotics control facility in an urban center 750 miles from the mines. One operator can monitor an entire fleet of trucks that run 24/7 with no need for lunch or bathroom breaks and no risk of on-the-job injuries.

A key global planning study titled “Mining a Mirage?” by the Canada- and Switzerland-based Intergovernmental Forum on Mining concludes that automation is transforming the industry far faster than mining companies anticipated. And why wouldn't it, since automated mining is slated

to reduce operating costs by 50 percent and increase productivity by 30 percent? These efficiencies result largely from workforce reductions, which could be as large as 75 percent, according to references cited in the study.

When? The study notes that these technologies “are likely to reach their peak rates of deployment in the next 10 to 15 years.” That’s years before Twin Metals, even under its rosiest projections, anticipates having a shovel in the ground. By then, how many of the promised 850 mine-operator jobs will have been eliminated by automation?

In that same 10- to 15-year time frame, driverless trucks are expected to eliminate the nation’s most common job: our 3.5 million truckers. The driverless semi named “Otto” that transported 50,000 cans of beer across Colorado this summer might have been an Uber stunt — but it worked.

Minnesota’s Eighth District U.S. Rep. Rick Nolan, a Democrat who sits on the House Transportation and Infrastructure Committee, is well aware that the equipment-operator workforce is facing its demise within the next decade or two. But yet he panders for the vote of mining proponents while giving no hint that the jobs they hope for their children are rapidly destined for obsolescence — unless their kids want to monitor computers at a robotics control facility in an urban center hundreds of miles from Ely.

The “Mirage” planning study also concludes that, in socioeconomic terms, the traditional “social license” by which communities allow corporations to extract local resources in return for local jobs needs to be renegotiated — because the next generation of mines will offer few locals jobs. Here’s another opportunity for Nolan, or whoever replaces him, to exhibit some political leadership.

These sweeping automation trends mean that, with or without Twin Metals, mining employment will not be a significant factor in Ely’s workforce future. Every community in the country will need to reckon with this “mother of all” industrial revolutions. Fortunately, Ely is ahead of the curve with our downtown revitalization and burgeoning small-business movement.

References to our “amenities-based economy” may raise some eyebrows, but there’s no denying the fact that if we take care of our woods and water, Ely will always remain an appealing place to live, work and recreate. But its sustainability cannot rely upon the fading mirage of heavy-industry jobs.

Paul and Susan Schurke are owners of Wintergreen Northern Wear and Wintergreen Dogsled Lodge in Ely.

<http://www.startribune.com/watch-out-ely-mine-robots-are-on-the-way/451966383/>

White Paper

Next Level mining

Securing the future through integrated operations & information technologies



Next Level mining

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Executive summary

The mining industry needs to innovate or risk its long term viability. In today's rapidly changing and uncertain times the status quo will not deliver desired shareholder returns.

Mining leaders need to think ahead and work out how technology will transform the basics of their operation, their customers and their supply chain. They need the vision

to see how technology can increase sales and profits by synchronizing the demand chain and improving customer service, while reducing operating costs from operations through to suppliers. The future of mining belongs to those advanced companies able to recognize today the benefits that automation technologies will bring to the entire mine operation.



1.0 Evolving market dynamics: an even greater shift in productivity needed

The last century saw tremendous improvements in the mining and minerals sector. However, given evolving market dynamics, said gains are insufficient to ensure long-term growth and productivity.

Figure 1 outlines the four step-changes which have seen radical productivity gains.

For example, the gradual mechanization of underground mining in the first half of the 20th century, including the development of conveyors, loading machines and drill rigs, dramatically increased tonnage per worker.

More recent advances like long wall mining equipment, driverless trucks and recent developments in remote operations and control systems, enable today's miners to produce many times the ore with fewer workers and under safer conditions than ever before.

The difficulty now is the fact that the first three step-changes have been exhausted: haul trucks are already big, pits are supersized and infrastructure is being pushed to its limits. Future mines will need to adapt significantly in order to address today's formidable market conditions.

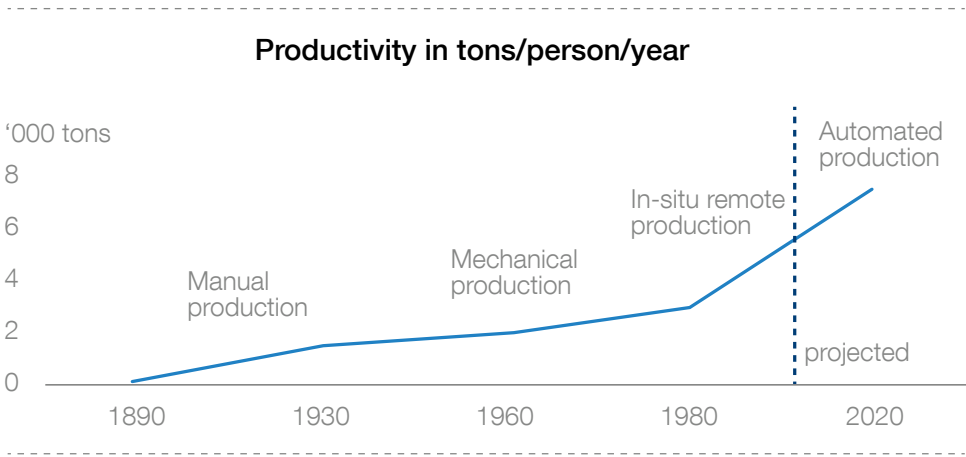


Figure 1. The productivity shift.

Labor-intensive	Mechanization of key processes	Limited automation	Mines of the future
Hardly any value chain visibility	Limited value chain visibility due to manual & paper based processes Equipment operation still requires human interaction	Some degree of automation driven by labor shortages and remote mining locations Greater visibility into parts of value chain Ability to mine remotely given more information coming back from plant & equipment	Integrated modeling and planning generating higher quality mineral yield High levels of visibility across value chain and across operations with artificial intelligence Bottlenecks limited by adopting more continuous processes

2.0 Challenges facing the mining industry

The mining industry faces many external market and internal business challenges.

2.1 External market challenges

Changing market dynamics are driven by:

Harder to reach deposits

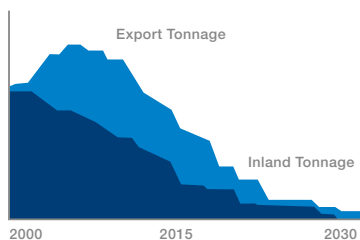
The easily accessible deposits are being rapidly depleted. New ore reserves are more technically challenging to extract and are located in remote or politically complex regions. Getting to this ore means going deeper. As costs go up, so must productivity if mining companies are to stay profitable. Furthermore, going deeper carries more risk and the fewer people that work at depth the better it will be for mine safety. Technology is evolving rapidly, bringing the ability to extract more from less and to go significantly deeper and more profitably than ever before.

Increasing commodity prices

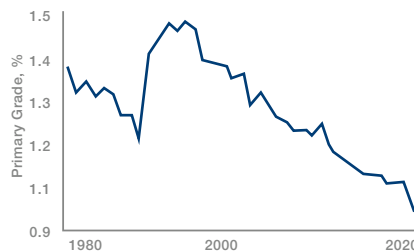
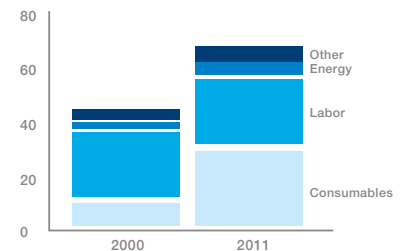
Over the past five years commodity prices have remained reasonably flat, or have declined. High price volatility caused, in part, by supply disruptions, tight markets and new pricing systems, is also having an impact.

Rising demand

Continued growth in demand, due to factors such as the increased industrialization of China, means that mine operators need highly flexible infrastructure in place so they can raise production quantities when needed. Even a modest three percent growth per year results in a doubling of demand in just over 20 years — not a long time in the framework of mining.



Source: Xstrata Copper



Reserves are depleting in some commodities. Assets and ore bodies are becoming more complex

Ore grade quality is declining

Labor is more costly, energy costs are going up and doing business in new markets is putting pressure on margins

The bottom line: continuing to deliver high shareholder returns in changing times

Figure 2. Mining industry trends.

2.0 Challenges facing the mining industry

2.2 Internal business challenges

The industry is being driven by a plethora of business hurdles including, but not limited to:

- Fragmented communication
- Lack of collaboration between different departments and across the supply chain
- Maximizing aging capital assets
- An aging workforce
- Improving safety
- Energy volatility

The careful integration of technology can help overcome these challenges by increasing visibility, improving communication and eliminating duplication, all of which has a positive impact on the bottom line as well as employee safety and morale.

Challenge	Issues	Benefits of technological approach
2.2.1 Overcoming disjointed communication and information silos from within the mines	<ul style="list-style-type: none"> – Many independent pieces of equipment and systems, each with its own data and interfaces – Duplicated activities and costs <ul style="list-style-type: none"> – Different sites and departments run their own procurement activities – Difficulty making timely, effective decisions to manage disturbances due to lack of common visualization of mines <ul style="list-style-type: none"> – Technology has grown in a diverse and chaotic way resulting in fragmented islands of automation where: <ul style="list-style-type: none"> – Operators and control room staff view different screens and have separate pieces of information at hand – Managers feel they are drowning in data but are unable to find the answers they need – Insufficient real-time data – Over-reliance on operator skill <ul style="list-style-type: none"> – Production scheduling is manual, reliant on the skill of the scheduler and often carried out without due consideration to the overall supply chain 	<ul style="list-style-type: none"> – Changes how miners view and interact with their operations and markets <ul style="list-style-type: none"> – Allows greater visibility of operations by integrating information technology with that of operational technology – Helps overcome inefficient scheduling, waste and labor intensive activities <ul style="list-style-type: none"> – Scheduling integrated from mine operation to shipping, including blend design and dynamic order book allocation to stocks in the system wherever they are – Mine/plant throughput maximized given production supervisors can now use technology to juggle many more variables than before – More strategic and better integrated procurement programs – Enables mines to be more responsive and flexible – Enhances delivery performance <p>As a result mines benefit from:</p> <ul style="list-style-type: none"> – Increased production and revenue – Reduced operations cost and improved margins – Better return on capital employed

Challenge	Issues	Benefits of technological approach
2.2.2 Leveraging collaboration across the entire supply chain	<ul style="list-style-type: none"> – Elements of the supply chain are isolated from each other <ul style="list-style-type: none"> – Suppliers, customers and partners rarely interact – Mining teams in remote locations hardly ever talk with a central control room or other mines – Missed opportunities to develop novel approaches to operational challenges – Insufficient sharing of best practice <ul style="list-style-type: none"> – Reinventing the wheel time and again 	<ul style="list-style-type: none"> – Enhances productivity and performance – Helps resolve common issues more quickly and effectively <ul style="list-style-type: none"> – Shared knowledge can result in more accurate plans (eg, forecasting) – Allows teams to communicate and collaborate across the enterprise including multiple mines and sites with activities being coordinated through a central control room or location – Potentially builds customer loyalty and may identify new revenue streams <ul style="list-style-type: none"> – Due to technology, innovation and R&D being shared more easily and frequently throughout the company and with partners, vendors, suppliers, customers and other supply chain parties where appropriate

Challenge	Issues	Benefits of technological approach
2.2.3 Managing aging assets to minimize downtime risk and its impact on profitability	<ul style="list-style-type: none"> – Reactive and time-based maintenance are dominating maintenance strategies – As a result of a fragmented approach to asset management – Lack of data acquisition systems and real-time data complicates more proactive strategies – Every moment of unplanned, reactive downtime is costly, not just for the repair itself, but also because the asset is down and not producing revenue with potentially disastrous effects on profitability – Performed separately across sites or geographies often involving manual or unconnected information, processes and systems – Isolated from other business planning functions 	<ul style="list-style-type: none"> – Reduces time, expense and downtime through real-time condition and health monitoring – Assets are instrumented, interconnected and intelligent, reporting their location, status and other key metrics remotely and automatically – Facilitates preemptive condition monitoring using systems with predictive data modeling to trigger maintenance orders and prevent breakdowns before they happen – Helps determine the optimal way for these assets to behave and interact with each other by providing a view of the entire asset management life cycle – Asset management is integrated with other business functions and systems such as enterprise resource planning and documentation thereby enabling better control over costs

Challenge	Issues	Benefits of technological approach
2.2.4 Dealing with an aging, difficult-to-replace, workforce	<ul style="list-style-type: none"> – More than third of the industry relies on human intelligence to optimize its value chain – Much of the workforce is retiring <ul style="list-style-type: none"> – Transferring their knowledge and experience to the new generation is a challenge, especially as the experts are dispersed and often unavailable – Difficult to recruit and retain competent staff to run mining operations in remote and inhospitable locations – Newer employees have different attitudes and expectations 	<ul style="list-style-type: none"> – Expedites execution thereby generating higher productivity and margins as knowledge is captured and delivered to the right workers at the right time – Optimizes expertise of global workforces through virtualization and remote operations – Promotes an optimized management set up with centralized organization and reduced cost structure via efficient and rapid decision-making – Streamlines administration to reduce costs – Makes mining appear an attractive career option for high-tech graduates by demonstrating industry focus on environmentalism and corporate responsibility

2.0 Challenges facing the mining industry

Challenge	Issues	Benefits of technological approach
2.2.5 Improving safety through better prevention and quicker ability to address problems effectively	<ul style="list-style-type: none"> – Dangerous conditions for workers, contractors and visitors especially in underground areas – Hazardous environments – Possible collisions and accidents with machinery – Potential mine collapse and ventilation failure resulting in exposure to toxic mine gases, explosive gases and dust 	<ul style="list-style-type: none"> – Detects and avoids collisions through smart programs and technologies such as location awareness, GPS and radio frequency identification – Tightens site security by deploying automated identity and security management programs that centrally track employees' access rights, location, duration, training, safety certification, permissions and compliance – Cuts downtime, insurance costs and litigation, while improving employee retention, recruitment and morale by reducing injuries and fatalities

Challenge	Issues	Benefits of technological approach
2.2.6 Coping with energy volatility	<ul style="list-style-type: none"> – Increased government regulations globally: <ul style="list-style-type: none"> – Australian Emission Trading Scheme – European Union Emission Trading Scheme – Kyoto Protocol – Manual management of carbon, water, energy and waste with currently little automation or integration – Perception that mining is environmentally unfriendly – Little or no integration between the processing and power parts of many mine operations, making it difficult to determine where energy is actually used 	<ul style="list-style-type: none"> – Current technologies and programs track and monitor carbon, water and fuel from end to end and extend to footprint management, waste management, ecosystem risk management, mine closure and re-habitation, tailings placement management and stewardship management – Technology helps reduce energy expenditure and regulatory costs – Processes, information and analytical tools are used proactively to manage environmental and energy consumables, such as modeling carbon trade-offs, carbon trading, water management, fuel optimization and waste control – Reduced management costs and improved effectiveness in the control of consumables that impact the environment (e.g. carbon, water, energy, waste) – Tighter compliance with regulations and reduced costs of meeting/monitoring regulations

3.0 The future vision for mining

All of the competitive pressures facing the mining industry (see section 2.0) are driving mine operators to find new ways to increase the production rate of their operations, reduce the cost per tonne produced and extend the life span of mine sites or establish new ones. These factors are fast becoming critical competitive differentiators.

Mine operators need to change totally from the model of digging out the ore and putting it onto the market to one where they respond quickly and efficiently to customer relationships and demands, providing the ore where and when it is needed. They need to be capable of rapidly responding to new opportunities by becoming fluid, flexible and agile.

The vision is one where, in the future, mines will have equipment closer to and people further from the processes. Technology, machinery and robotic automation will be doing the routine and repetitious jobs, while personnel attend to more strategic tasks.

Taking people away from the process will reduce cost, increase productivity and enhance safety by enabling remote monitoring, diagnostics and interventions. It will see a skeleton on-site workforce collaborating with external specialists and supervisory staff based in remote operations centers.

This will be achieved by moving automation and electricity to where the ore is extracted, minimizing haulage and transport. It will see a plethora of technology to assist miners in their roles such as fully and semi-autonomous robots, increased use of artificial intelligence, 3-D and 4-D printing and ever more innovative technologies that allow remote operations.

Soon mine workers will be using big data, analytics and real-time information to guide and inform their work. Their clothes, tools and surroundings will all contain technology, each specific to a data collection task, but collectively amassing information on the miner and the mine's condition, work completed and yet to be finished as well as the mine surroundings and with the sophistication to adjust work conditions and tasks accordingly.

The solution to all these challenges, and thus the future of mining, lies in the automation and integration of information - and the use of that knowledge for real-time optimization of the mining processes.



3.0 The future vision for mining

3.1 Bringing together information and operational technologies

All of this is enabled by greater integration, visibility and intelligence within and among the operational technology (OT), production control systems and information technology (IT) that manage the company's critical assets, logistics, planning and operations. The result is unprecedented agility in operations and to both supply and demand fluctuations.

As the convergence of IT and OT brings more information from real-time systems into IT software, the following are among the four "must-have" benefits that will enhance efficiency, responsiveness and profitability across the mining value chain:

- Smart production
- Intelligent response to critical asset condition
- Demand-driven planning
- Reduced energy consumption and waste

Yet a major challenge for mining companies to reach their goals is a lack of integration between IT and OT systems. A growing number of mining companies see the single leading benefit of IT/OT data integration as optimizing for cost and efficiency. This directly addresses the challenges of:

- Managing ever increasing costs
- Controlling energy expenditure and efficiency
- Optimizing or maximizing production

Unfortunately, many companies have little or no data integration across the value chain and still operate in silos, with data not being shared with other departments. Many still rely on spreadsheets combined with human expertise for crucial decision support.

But, things are changing with several companies now taking steps to implement IT/OT data integration. These companies have a consolidated view of production systems and the most advanced these can dynamically view and adjust operations across the value chain.

It would appear that a growing number mine operators understand that IT and OT cannot operate in silos if they are to continue to deliver good shareholder returns in light of increasingly difficult extraction realities.

Many are coming to the realization that, to address emerging challenges effectively, operators need an integrated solution which provides remote asset diagnostics, continuous automation and production optimization.

ABB has been working for over 10 years to develop and enhance process control systems, communications solutions, sensors and software for the Internet of Things, Services and People. These technologies enable customers in industry, power generation and infrastructure to analyze data more intelligently, optimize their operations, boost productivity and enhance their flexibility.

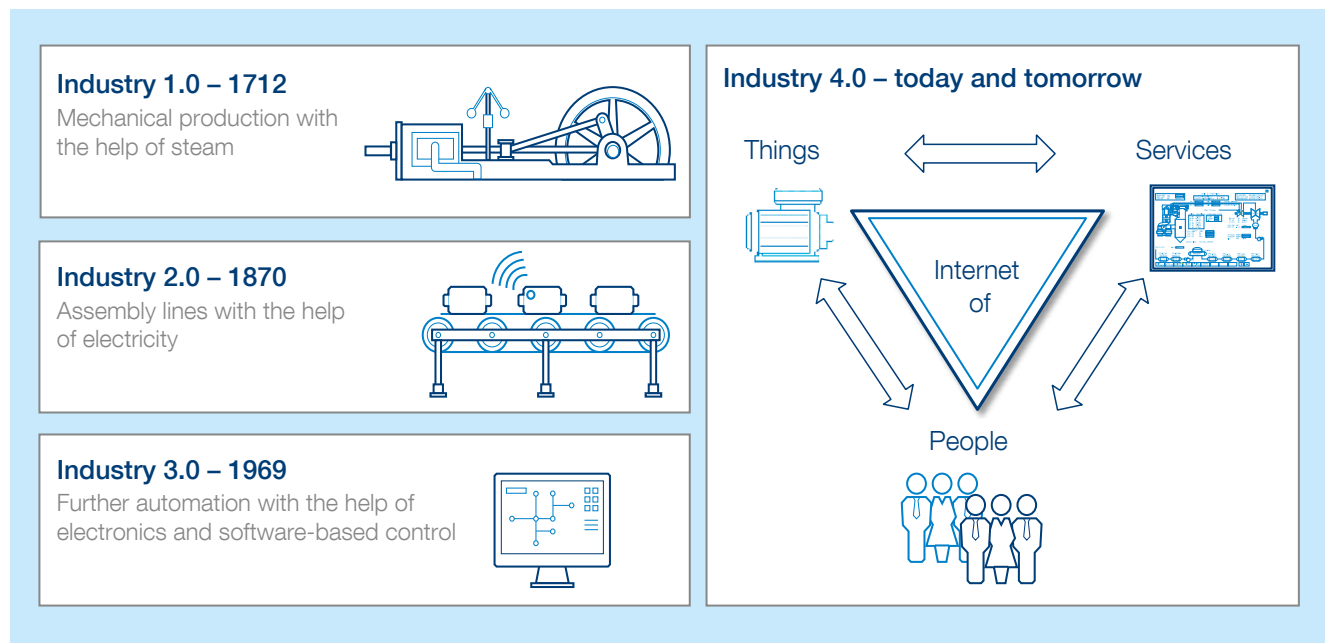


Figure 3. Industry's evolving future.

4.0 Optimizing the entire value chain

Today a typical mine and process operation has various areas in which operators run their own machines, often independently and without much communication or collaboration between them. There is rarely any integration between equipment and systems resulting in what is now frequently being referred to as islands of automation.

The challenge is to optimize the entire value chain, so that there is a complete and unified view of production, from raw material to processing, stock pile and delivery.

Integrating IT and OT helps close gaps in the value chain. For example, with good communication, blasting and crushing in the mine can be optimized together with the grinding process in the concentrator as a whole.

Automating every part of a mine brings significant benefits including:

- Higher productivity, enhanced collaboration
- Holistic commercial view of the whole enterprise
- Increased energy efficiency
- Improved safety

The future of mining lies in bringing equipment, systems and people together; the technology that can achieve this is automation.

4.1 Uniting the islands of automation

Taking the mine mentioned above, with its various independent islands of automation, the idea is to bring them together so that they talk the same language and are integrated into one system where all information is available. While local control rooms may still exist, the trend is towards centralized operations.

With modern control room designs, people with different roles can work together in the same environment. Barriers are torn down, control rooms are consolidated and experts can collaborate in one place.

Such extended automation closes gaps in the value chain and creates a safe, reliable and predictable production process with better visibility from mine to concentrator, smelter and stockyard.

The result is an optimized operation from mine to port.

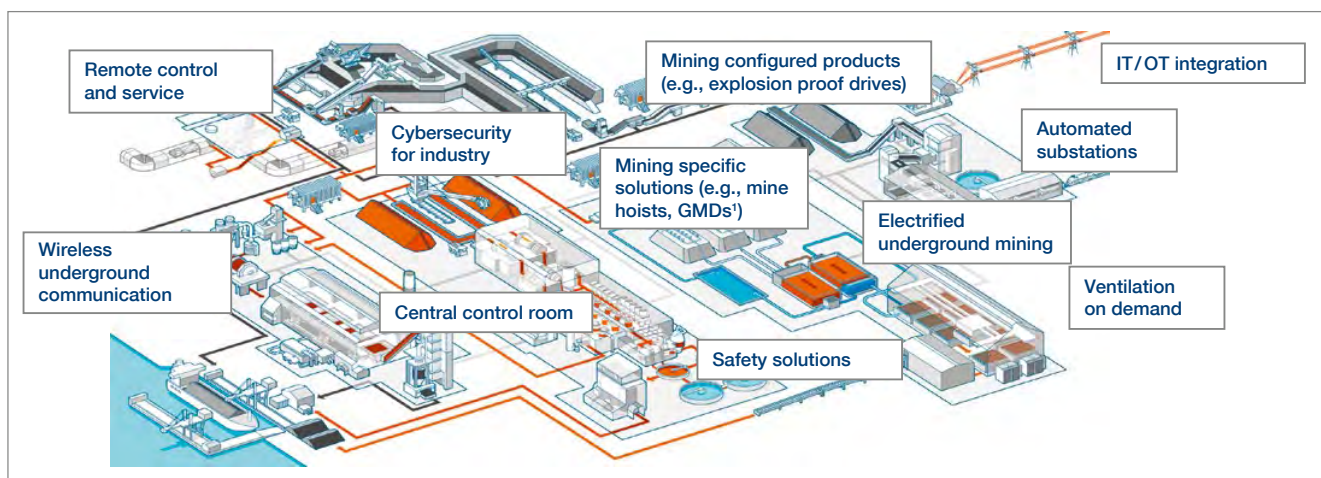


Figure 4. Automation touches every aspect of a mine.

4.0 Optimizing the entire value chain

4.2 Case study: Boliden Garpenberg mine

Boliden's Garpenberg mine has embraced the integration of automation and data to claim the mantle of the most integrated power and automation mining solution in the world. This facility recently underwent expansion of its underground mine that will see capacity rise from 1.5 million metric tonnes per/ year to 2.5 million.

To meet this demand, ABB has delivered an integrated power and automation control system across the value chain from mine to mill including:

- IT/OT integration, advanced process control
- Remote monitoring capabilities
- High-, medium-and low-voltage electrification, motors, and drives

And energy efficiency solutions that include:

- Ventilation on demand, smart switchgear
- Mining specific drive-motor packages

Along with a service agreement, based on preventive and condition-based maintenance.

The entire mine is now operated from a control center equipped with System 800xA, which controls most of the equipment and systems required to automate production and some of the business processes.

The Garpenberg mine is the first to integrate mine hoists, mine ventilation and the monitoring of underground mine vehicles. An integrated maintenance system allows for remote solutions for the control of the entire mine. In particular, Boliden uses mobile AF devices to supervise the production process and shorten the time for decision making.

"It's not a coincidence that ABB became one of the main suppliers", says Lars Brännström, Strategic Account Manager for Boliden. "Together with the customer, we discussed and developed the best solutions for the mine." Lars emphasizes how important it is to work closely with the customer to understand their needs, to listen carefully and to be flexible and make necessary changes during the project.

Facts about Boliden Garpenberg:

Boliden has invested 3.9 billion SEK to almost double the annual production by the end 2015. When under construction, it was one of the biggest construction sites in Sweden with over 700 people working on the project.

Dating back to the 1200s, Garpenberg is Sweden's oldest mine which is still in operation. Today, Garpenberg mine produces complex ores containing zinc, lead, silver, copper, and gold.

The project started in 2011 and this expansion will increase production from 1.4 million tons of ore per year to 2.5 million by 2015.



Figure 5. System 800xA on a mobile device at Boliden.

5.0 ABB's enabling technologies

ABB is ideally positioned to assist mining companies achieve the productivity transformation they are looking for with solutions spanning hardware, control and smart mining software.

ABB has been at the forefront of automating mining technologies - such as ultra-long-distance conveying and super-sized processing plant technologies - necessary to drive major physical infrastructure improvements. ABB has pioneered some of the world's most exciting technological advances in mining control systems and is a leader in the design and development of remote operations centers for some of the world's largest mining companies.

Going forward ABB's holistic approach to the entire mining operation will feature smart devices and equipment - enabled for autonomous configuration, efficient operation and self-diagnostics – as well as software that delivers total, real-time transparency for the operators. This will provide visibility of resources across the mine; intelligent production based on near real-time demand, market conditions and available ore types; and an optimal response to critical asset conditions.

By harnessing the full potential of extended automation and by bringing people, equipment and systems together in a fully integrated environment, ABB firmly believes that mining companies can vastly improve productivity, workforce satisfaction and safety.

5.1 System 800xA

A report by ARC Advisory Group shows that ABB has retained its leading position in the worldwide distributed control system market. According to the study, ABB is the regional market share leader for Latin America, Europe, Middle East and Africa (EMEA) and the worldwide leader in key global verticals including oil and gas, pulp and paper, mining and metals. It is a pioneer of integrated power and automation control and process application software. For over 100 years

ABB has provided the mining sector with fully engineered products, systems and solutions for process control, safety, instrumentation, plant electrification and energy management.

The key to the future of mining lies in the total integration of data and work processes to achieve a process management that runs in real-time. For example, with a modern automation platform such as ABB's System 800xA, an entire mining operation can be controlled. Thus the blasting and crushing can be optimized together with the grinding operation and the concentrator as a whole, closing any gaps in the value chain. Harnessing the full potential of extended automation brings people, equipment and systems together in a fully integrated environment.

The System 800xA automation platform can handle traditional process control systems, distributed control systems (DCSs), safety systems and electrical equipment such as drives and motors, as well as production planning, power management, maintenance, asset management, enterprise resource planning and documentation systems. These can be integrated into a single control environment. The system can integrate different users, live video, voice and public address systems, plus web applications and devices. As well as ABB products, third-party pieces can be integrated into the process workflow.

With the System 800xA all information is available to all users, locally and centrally as well for mobile operators with iPads or smartphones.

By bringing together the islands of automation and ensuring that everyone has access to all information in real-time through the same viewing platform, there will now be one way to handle all functions and interface systems, one common language and one way of working with resultant efficiency benefits throughout the process.

5.0 ABB's enabling technologies

5.2 Extended operator workplace (EOW)

The EOW is a modern cockpit for mining operations. System 800xA ensures that information is available centrally to all users and locally, using mobile devices such as tablets or smartphones.

An EOW avoids the cluttered and scattered overview that operators currently endure. This environment can result in poor collaboration in which operators never have a true overview of the process and are more likely to make mistakes.

In fact the global process industry loses \$20 billion, or five percent of annual production, due to poor quality and unscheduled downtime. Consultants from the ARC Group estimate that almost 80 percent of these losses are preventable and 42 percent are primarily the result of operator error.

Integrating the data and presenting it through an EOW will enhance efficiency, responsiveness and profitability across the mining value chain. Integration on this scale will become the norm for all leading mining companies over the next few years — indeed, some are already well down this path.

5.3 Enterprise software

The 2010 fusion of leading mining software company Mincom into ABB created a dynamic entity with the technological know-how to supply the solutions needed to help mine operators make a step change.

The software solutions include planning, logistics, sales and marketing, asset management and business analytics software, covering the entire mining life cycle. The availability of leading-edge hardware, operational and information technologies from one global vendor has opened new horizons for mining companies looking to embark on productivity transformations.



Figure 6. Remote operation center: The EOW enables true collaboration.

6.0 Areas of automation

ABB's position in mining is to supply the complete data integration solution and many of the elements crucial for mining, such as gearless mill drives, hoists, complete plant electrification, ultra-long-distance conveying, super-sized processing plant technologies, integrated process control and optimization solutions, motors and drives systems as well as instrumentation and analyzer systems.

As a technology company with a long history of providing advanced technology to the mining sector, ABB is well aware of the major leaps in innovation that are now needed in the business. Due in part to the very harsh conditions encountered underground, mining has lagged other sectors as far as technology and automation is concerned, but ABB's experience in areas such as oil and gas, automotive, and pulp and paper brings a deep understanding of how challenges can be overcome, and allows the creation of a vision and a technology road map for the future of mining.

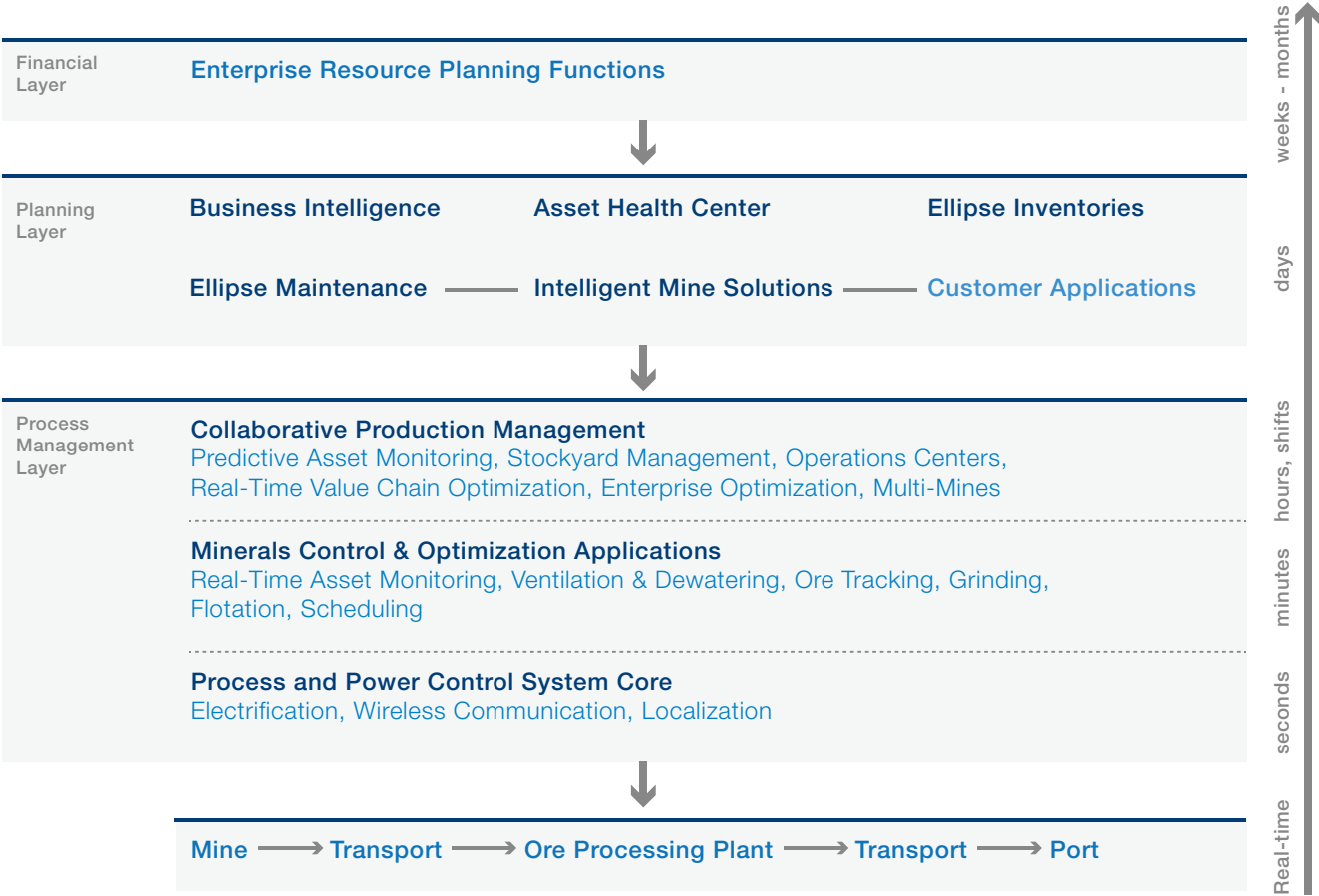


Figure 7. ABB extended automation portfolio for mining.

6.0 Areas of automation

6.1 Process and power control system core

With the vast power consumption of a modern mine, it makes sense to integrate the data from the electrical side with the rest of the operation. In this way, the power consumers — electrical machines, hoists, conveyer belts, ventilation, lighting and emergency systems — can work in harmony with the power supply infrastructure.

6.1.1 Mine electrification and its integration with process control

By integrating the process control and power control within the same system, capital expenditure (capex) is reduced, as is the need for training, IT infrastructure and cybersecurity.

Integrating this data within System 800xA with that from other parts of the enterprise achieves tangible savings. Maintenance procedures can then be tuned to take into account the condition of the machine to be serviced along with the wider

implications of taking equipment off line. Maintenance can be scheduled when other related equipment is nearing a service interval – or perhaps when market data indicates an upcoming dip in demand.

Significant energy savings can be achieved by combining market demand and production data - allowing machine activity to be optimally scheduled. There is no point in having maximum production rates (and thus highest energy consumption) if some bottleneck elsewhere in the enterprise is throttling production requirements.

Integrating process and power automation into one single automation system like the System 800xA reduces cost, enables effective power management and provides the mine operator with the starting point to make the technology step change now required by the industry.

6.1.2 Wireless communications

Integration of communications improves production efficiency. Once a wireless communication infrastructure is established and the mobile and fixed equipment fleet is integrated into this network, entirely new worlds of data exchange and optimization possibilities open up.

For example, ABB and Atlas Copco Underground Rock Excavation, Sweden, have developed an innovative mobile integration involving System 800xA and Atlas Copco's mining machines. The solution is currently installed in a mine in Kvarntorp, Sweden, and features the integration of real-time data from mobile machines, fans, faces and draw points, on-site crushers, conveyor and hoisting systems.

6.1.3 Resource location and data integration

Results reported by mobile equipment - such as online production reports or machine telemetric information - can be retrieved and analyzed in the context of location and status, including local environmental data.

With this information, new drill plans and loading sequences for production can be calculated and supplied to the operational teams. The International Rock Excavation Data Exchange Standard and other industrial automation standards will serve here as a starting point to ensure equipment compatibility across the industry.

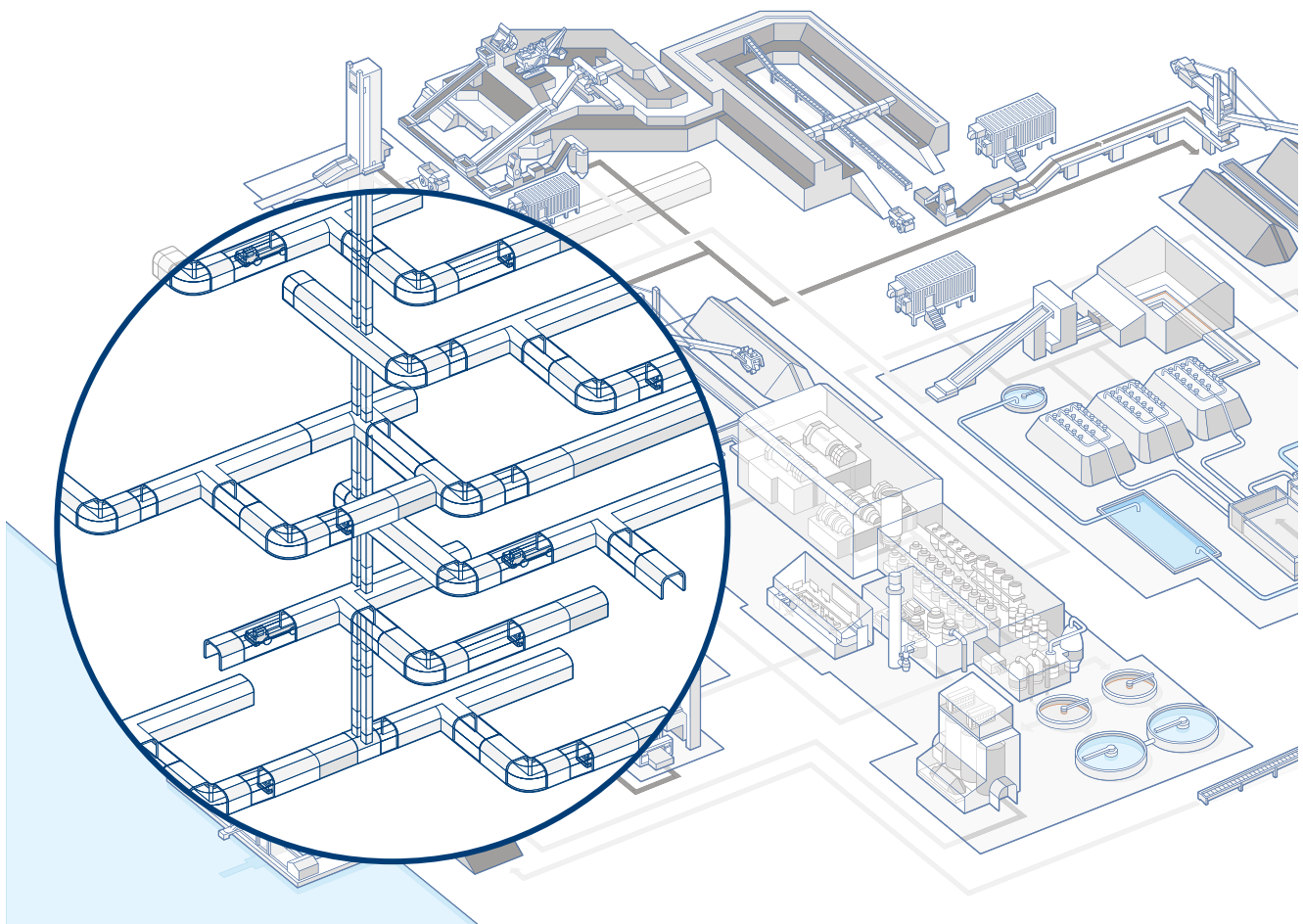


Figure 8. Wiring the mine to the control room.

6.0 Areas of automation

6.2 Minerals control and optimization applications

Information integration will dramatically improve production efficiency and productivity. This is particularly true when applications are created that exploit that information in the right context. The whole then becomes more than the sum of the parts. In this section a few examples are discussed.

6.2.1 Real-time asset monitoring meets process control

By using real-time condition data, in this case the temperature sensors on a conveyor drive, the actual condition of the asset can be detected, allowing proactive actions to be initiated automatically, greatly reducing the risk of potential failure which would cause a production loss.

There is a trend for putting planning and reporting and accounting systems more online.

6.2.2 Smart ventilation and mine dewatering systems

In some mines, ventilation accounts for almost 50 percent of energy consumption. Mine vehicles emit diesel exhaust gases that have to be ventilated away.

ABB's automation system knows the whereabouts of each vehicle. And, all vehicle data (including emission levels) is communicated to the system. The ventilation can therefore be

continuously optimized for actual need and the air flow can be adjusted at any time.

To manage ventilation on demand, a new method for mine-wide coordinated control of fans and air regulators optimizes energy use by automatically feeding the mine with the required air. The solution relies on feedback from gas, flow or temperature sensors.

Multi-variable models describe how changes in the speed of fans affect both the airflow and the pressure across fans. The parameters in the models are obtained empirically from operational data, which makes the model easily adaptable for new conditions.

Air is provided where it is needed in the mine by adjusting the fan speed based on the air demand in various airways, properties of the fans and their motors and as well as the opening angles of the air regulators that are used to control the air flow.

Minimizing energy consumption, while preserving air quality, means great savings. With the integration of process and power automation in System 800xA, energy usage can be measured in real-time. Through the EOW operators have a single view of process and power equipment, as well

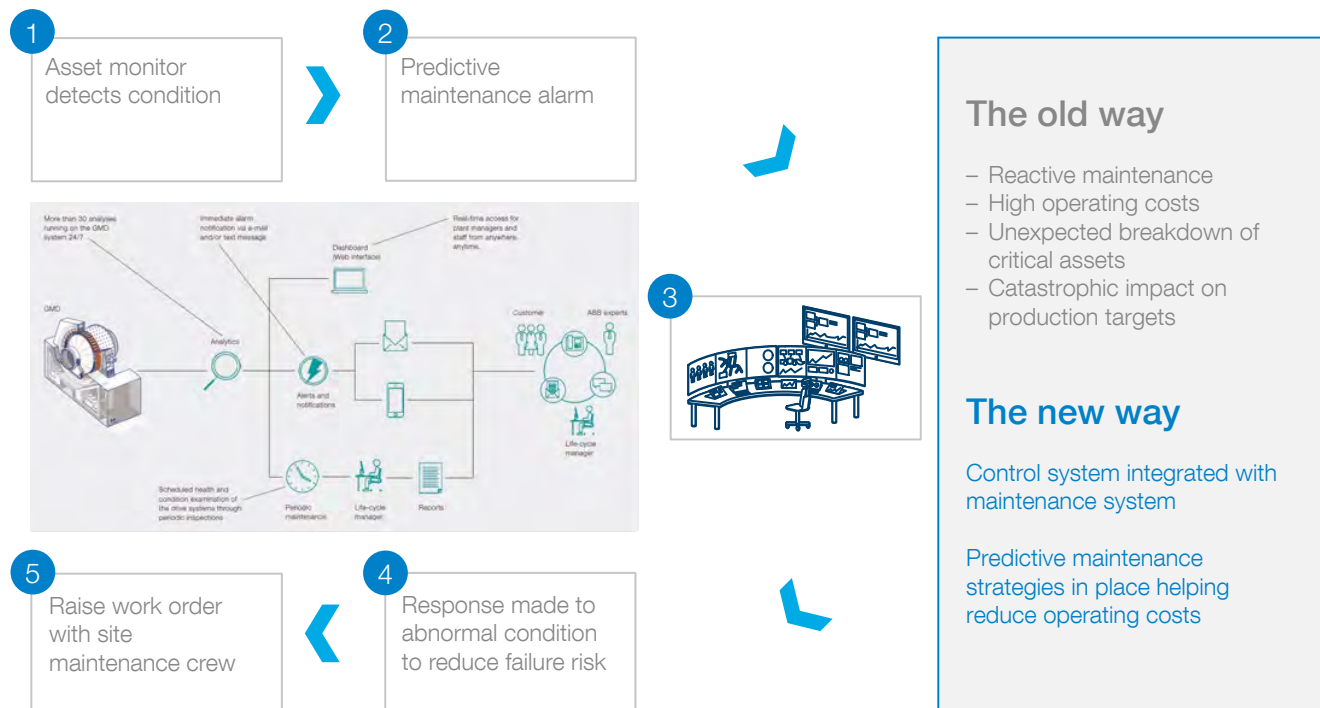


Figure 9. Optimizing processes through real-time asset monitoring.

as protection, switchgear, transmission and distribution equipment. The result is a reliable power supply and enhanced visibility of the usage and consumption of power in all areas of the mine.

Dewatering is another problem faced by miners both ancient and modern. Here, again, data integration can be used to great effect to monitor remotely pump condition and performance, maintenance needs, power costs and resource coordination. The energy savings to be made by optimizing pump performance in a mine can be very significant.

6.2.3 Ore tracking

In ore-processing plants, the largest source of uncertainty relates to the properties of the ore; plants need to be able to react quickly to any changes. Much better results can be obtained when the ore properties are quantified ahead of time.

Technology can track material movements and properties all the way from the mine to the processing plant. The software used to deliver this functionality is able to model the ore movements along the material handling system, including conveyors, silos and conic stockpiles.

Ore properties can then be logged and represented graphically, eliminating guess work. The information is available for other advanced applications, as well as to support operator's actions.

Material movements can then be automatically synchronized with inventory management systems that look after the logistics and the supply chain.

Finally, ore information can be used by process optimization controllers. They can use forecasts of the ore properties to make predictive adjustments to the grinding and flotation circuit. The result is higher equipment utilization, increased production and lower energy consumption.

Process optimization controllers exploit these forecasts to make predictive adjustments to the grinding and flotation circuit according to the now known properties of the ore. The result is higher equipment utilization, increased recovery and lower specific energy consumption. Production is within specifications, incurring no penalties yet guaranteeing customer satisfaction.

6.0 Areas of automation

6.2.4 Grinding circuit

A milling circuit is a complex, multi-variable interacting system. Dynamically changing ore conditions and wear parameters pose particular problems for grinding controllers. By integrating data, the automation system optimizes grinding controls, avoiding the need for constant manual tuning.

Again, data integration is key. The grinding process can not only be optimized within itself, but because it has access to relevant data from the rest of the mining operation, it can obtain far more leverage. Feed-forward data on ore quality and quantity, rock face production rates or market demand rates can be used to optimize the grinding stage.

6.2.5 Flotation circuit

Automatic control can lead to significant flotation performance improvement. The controller needs to stabilize the process and to maximize the concentrate production, while guaranteeing a minimum concentrate quality. This pushes the process to an upper limit operating point. To achieve this, optimal set points are automatically chosen by the controller. Online analyzers and blending algorithms reconcile actual feed with quality specifications for better predictability.

The mine operator can now increase plant recovery and optimize product mix by leveraging ore monitoring and advanced process control (APC) across processes and business systems. APC manages blending, grinding and flotation in real-time. Geological models and real-time material tracking provide a short-term feed characteristic schedule to the APC so it can increase performance and quality in real-time.

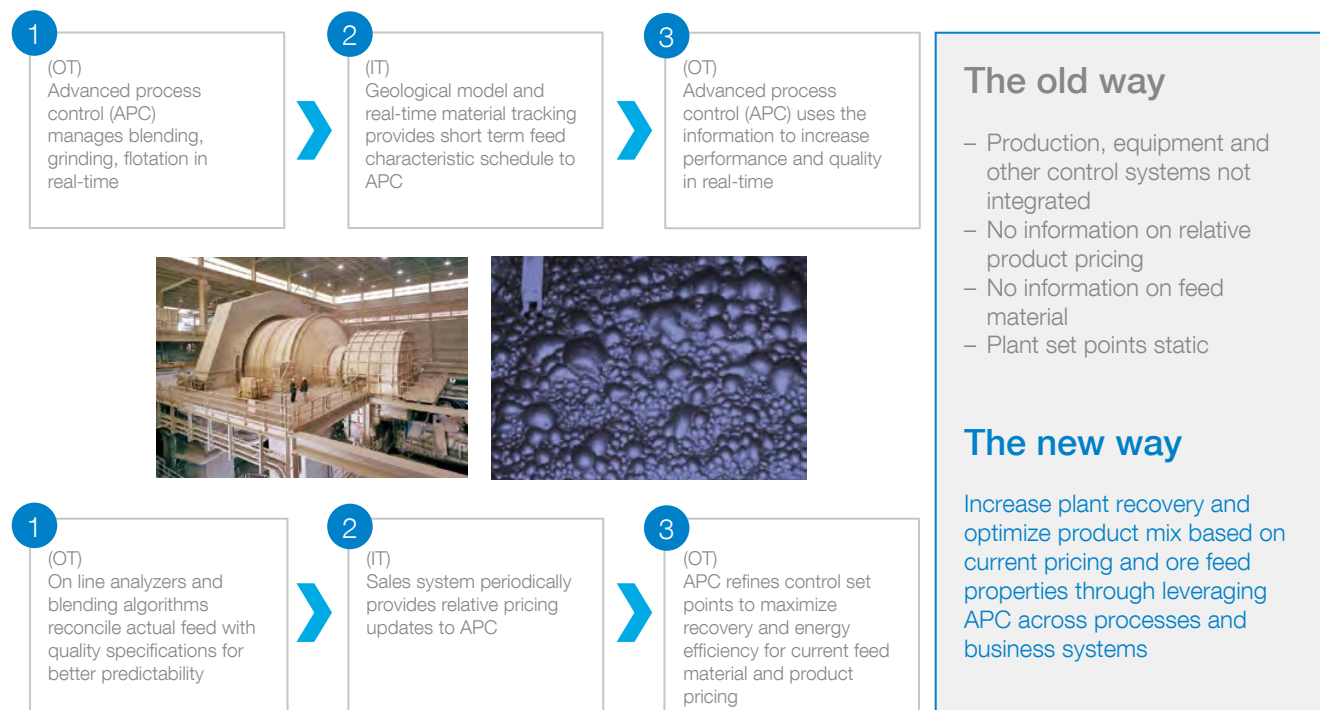


Figure 10. Grinding and flotation advanced process control.

6.2.6 Mine operation scheduling

Another typical mining scenario which could be optimized through automation is scheduling. Let us assume that a drilling cycle has missed a blast round. In this case the disturbance is putting the production at risk. With automation the local operator has a scheduling system in his workplace and gets notified immediately. The critical area is clearly marked and the cause of the problem is identified.

Operators and production management can discuss among themselves and run what-if analysis to simulate different solutions. Since all staff see the same information, they can jointly decide what actions to take.

Everything is done in real-time; no need to wait until the end of the shift.

With access to data from other parts of the operation, mining methods can move toward a large-scale, continuous mine operation that can be run as a normal factory.

The extended automation infrastructure created brings visibility and transparency to operations. The modern operator can act as a dispatcher or “flight controller”. This operator knows the daily and weekly plan, which resources are in place and has decision-support tools to optimize the usage of these resources to fulfill the production plan more effectively. This system allows the operator to detect anomalies faster and re-assign resources in order to minimize any impact.

Effectively, ABB is enabling manufacturing processes in the mining environment. This brings improved safety, higher production and better productivity.



Figure 11. Integration of key information facilitates effective decision-making.

6.0 Areas of automation

6.3 Collaborative production management: integrated-mine-to-port value chain operations

Automation is not new to mining, but the automation employed in mines is generally more basic than in other industries. It is often limited to simple control of motors, equipment or certain parts of processes. Further, mines tend to have a large number of independent pieces of equipment and systems from different suppliers. Each of these “islands of automation” can have its own data, data format and interfaces, and operators and control room staff must scrutinize a multitude of conceptually disconnected screens in order to coordinate different parts of the process.

6.3.1 Predictive asset monitoring

A modern asset optimization system can help mines to go from reactive to predictive maintenance strategies, avoiding unnecessary maintenance and reducing operating costs.

Extended automation solutions such as System 800xA can integrate modern maintenance systems from suppliers such as IBM, SAP and Ellipse from Ventyx.

A good example of this is the integration of IBM Maximo at Boliden's Aitik mine in northern Sweden. With System 800xA, the operator is alerted by a predictive maintenance alarm if equipment needs repairing. They can access the maintenance system, see all upcoming work orders and easily add new orders. The field engineers can view the same information on their mobile devices and together they can decide on the optimal maintenance plan.

Continuous and consistent asset monitoring brings maintenance management to the operator environment and provides a single-window interface for all operations related to asset management. This allows plant personnel to collect, compare and monitor asset data and thus accurately assess equipment conditions in real-time.

System 800xA's asset monitoring functions for mining combine automation architecture with advanced information technologies, including integrated fieldbus. Called AssetVista™, the function monitors all plant assets in real-time. This includes field devices, control systems and automation elements, as well as major assets such as heaters and generators.

The AssetVista™ architecture and functionality promotes the creation of complex asset-specific monitors that not only makes use of the raw device data itself but also integrates it with process and environmental information to put the data into context and deliver more precise condition statements.

This concept can be extended to complete production areas such as hoists, conveyors, mills and grinding and flotation circuits, thus creating a new level of insight into plant performance.

System 800xA AssetVista™ can thus help end users sustain asset management improvements and improve return on investment. It is a single point of contact to find the asset management solution that best fits user needs.



Figure 12. 800xA AssetVista™ dashboard.

6.3.2 Stockyard management system

Bulk material handling facilities transport material from one of several locations, such as a mine, to a destination. Often, bulk material is temporarily stored in stockpiles or stock yards. Stockpiles are used in many different areas, such as mines, ports, refineries, power plants or manufacturing facilities.

To increase production efficiency, optimize process output and reach an accurate and transparent input/output balance, a high degree of operator support and automation is necessary. This can be provided by a stockyard management system (SMS). An SMS is an integrated part of the overall stockyard management and control system and it includes instrumentation, electrification and scope for automation of operator-controlled stockyard machines.

A SMS organizes the stockyard in real-time based on job definitions generated by production management. The SMS merges data on incoming material quantities with

additional information such as quality data, ownership of material and localization and visualization aspects to provide a comprehensive picture. An “anti-collision system” at the control level provides for safe operations.

6.3.3 Remote operation centers: visibility and collaboration

The mining industry is gradually moving towards mine control through remote operations centers that coordinate multiple areas within an operation and even across multiple sites.

Local control rooms may still exist in the future, but the trend is overwhelmingly towards centralized operations — often in company headquarters. With modern control-room designs and extended automation, people with different roles can work together in the same environment.

Control-room consolidation means that barriers are torn down and experts can collaborate in one place.

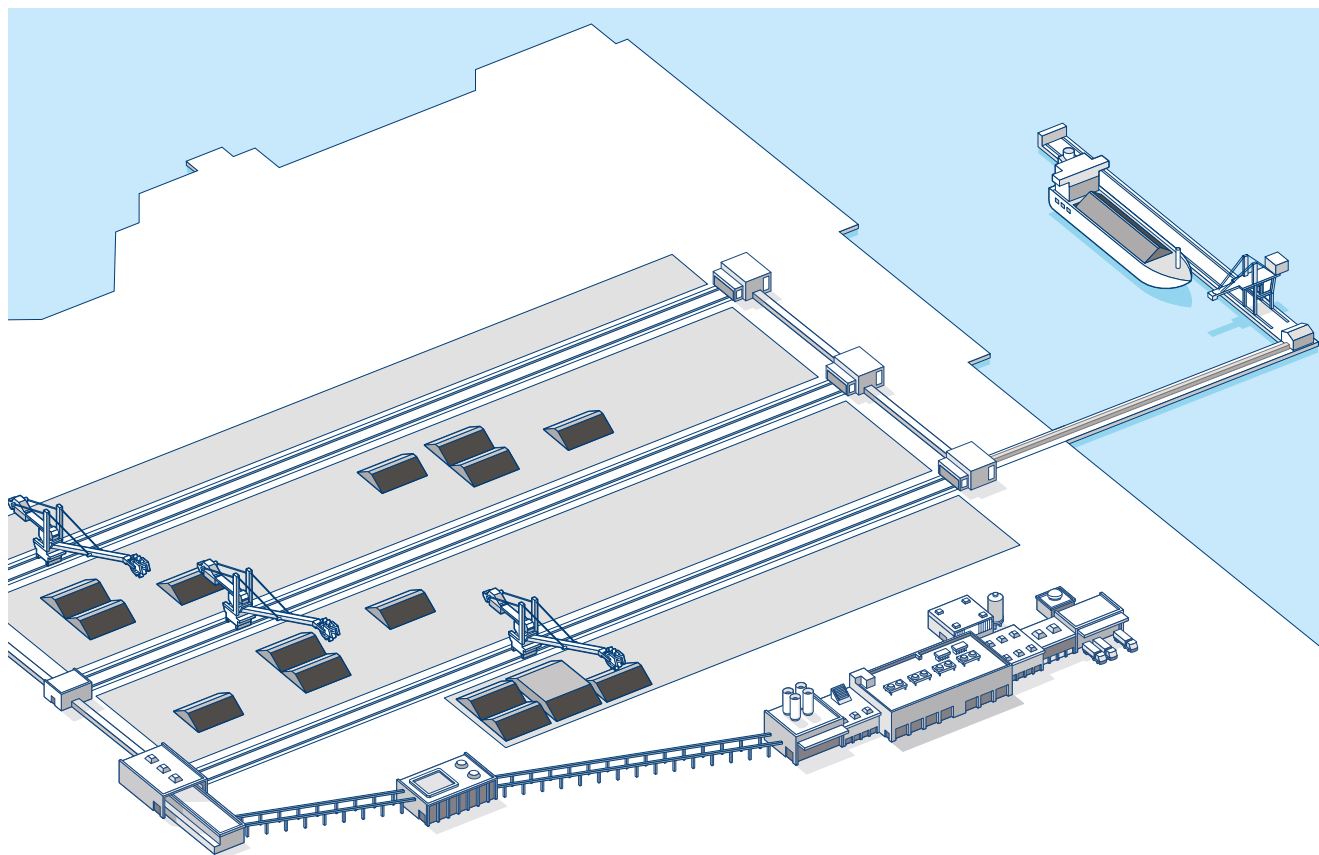


Figure 13. Stockpile management system.

6.0 Areas of automation

As all information from local mine sites is available, this facilitates collaboration in production planning, resource planning, specialist support, inventories and spare parts, allowing resources to be optimized across multiple sites.

Data from all parts of the operation can now flow together to allow precise and optimized management of mining - from rock face to end customer - across multiple sites. This collaboration between systems, equipment and people enables information to be shared without barriers and empowers operators to perform optimal control actions and to take sound business decisions.

6.3.4 Real-time value chain optimization

The mining value chain extends from the extraction of raw materials through the transport of product to the end customer. To achieve production and productivity targets, mining companies need to achieve high operational performance and efficiency across supply chain processes.

Among the principal causes of supply chain bottlenecks are difficulties in inventory planning, output planning and demand forecasting. These challenges in marrying supply to demand often result in inefficient production flow, large stockpiles and the inability to provide customers with the product grades they desire.

Better integration and automation across processing plant operations, mine planning and asset maintenance/management offers visibility into all production variables including delivery contracts, current inventory, mine plans, equipment availability and transport schedules and will guarantee the right product is available at the right time. It will also make sure that customer orders are accepted only when the supply chain can deliver, improving negotiating

power and risk management. Real-time material tracking and geological modelling can provide short-term input to rock face operations. In addition, this unified view ensures that equipment maintenance can be planned to suit increases or decreases in demand.

To further anticipate demand, information can be supplemented by market-based demand information such as stock levels, customer demand trends as well as fuel and commodity pricing. In a coal mining value chain, for instance, visibility into real-time conditions can be provided by online coal quality analysis sensors.

When these indicate that the actual blend deviates from the target, a control sequence could automatically be triggered that interrogates the inventory data. Based on stockpile information, reclaiming can then be automatically adjusted so the customer's specification is met. The result is production within specifications, with no penalties and guaranteed customer satisfaction. This holistic view enables the full implications of short-term, medium-term or operation-recovery decisions to be understood, improving the overall performance of the entire operation.

6.3.5 Big-data-based enterprise optimization

The underground environment takes its toll: the utilization rate of mobile mining machines can be as low as 20 to 25 percent, that of open faces as low as 20 to 30 percent and some machines can have a mean time before failure as short as eight hours.

Failure of a critical production asset can have a catastrophic impact on production targets and profits. The loss resulting from a main conveyer failure, for example, can run into hundreds of thousands of dollars per hour.

A modern asset optimization system can help mines to go from reactive to predictive maintenance strategies, avoiding unnecessary maintenance and reducing operating costs. In future, online access to experts 24/7, online integration of relevant information and online integration of tools and inspection devices will be taken for granted. System 800xA can integrate modern maintenance systems from relevant suppliers. Real-time data on asset conditions can then be used to streamline maintenance effectiveness and enable condition-based monitoring.

In the case of a conveyer system, say, if an asset monitor were to detect an abnormal condition, an alarm would be generated and the control system could slow the drive to reduce failure risk. Once integrated, these systems would connect directly into the IT systems and automatically raise a work order with the site maintenance crew. When the crew completes the work, this could be instantly reported, allowing the control system to return systems to normal in the shortest possible time.

In future, the equipment across a company's mines will be completely standardized. This not only makes life easier for operations and maintenance staff, but also it makes a lot of sense now that each piece of equipment can be included in the big picture back at the remote operations center.

6.3.6 Multi-mines

Mining companies have become multinational giants with mines scattered all around the world.

With System 800xA all information from local mines can also be available and consolidated into corporate headquarters. This facilitates collaboration across mines. Production planning, resource planning, specialist support, inventories, spare parts, etc can be optimized.

By harnessing the full potential of ABB's extended automation, mining companies can raise their productivity and safety, and achieve a more efficient and profitable mining operation.

Conclusion

ABB is committed to the mining industry and has a research program that aims to extend automation and integration to even more complex mining scenarios. For instance, research is underway on the next generation of networking technologies to enable tracking and communication of production equipment in open pit and underground operations. New sensor technology is being developed to detect mass flow and quality variations more quickly and accurately across a range of commodities. Meanwhile, advanced process control models are being explored that will improve energy efficiency while new asset health monitoring technology is set to detect more proactively actual and predicted capacity loss.

A holistic approach to the entire mining operation will feature smart devices and equipment — enabled for autonomous configuration, efficient operation and self-diagnostics — as well as software that delivers total, real-time transparency for the operators. This will provide visibility of resources across the mine; intelligent production based on near real-time demand, market conditions and available ore types; and an optimal response to critical asset conditions.

By harnessing the full potential of extended automation and by bringing people, equipment and systems together in a fully integrated environment, ABB firmly believes that mining companies can vastly improve productivity, workforce satisfaction and safety. The automation journey for the mining industry has just begun.

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MINING A MIRAGE?

Reassessing the shared-value paradigm in light of the technological advances in the mining sector

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Mining a Mirage? Reassessing the shared-value paradigm in light of the technological advances in the mining sector

September 2016

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Executive Summary

Introduction

The concept of shared value is becoming a linchpin of the modern mining sector. It goes beyond companies focusing on community investment and philanthropy approaches, and argues that firms can bring value to both themselves and their host communities, regions and countries by any of three different means:

- 1) Reconceiving products and markets, innovating to ensure that their products serve market needs and do as little harm as possible.
- 2) Redefining productivity in the value chain, looking for improvements in logistics and in the use of energy and other resources.
- 3) Building supportive industry clusters at the company's locations, focusing on mutually beneficial improvements in infrastructure, supplier capacity and human resources.

In this paper, we consider what changes in technology might mean for the third of these avenues, focusing specifically on the ways in which firms add value to economies through their procurement of goods and services, and through employment. These categories of expenditures in our two case studies amounted to 30 per cent and 80 per cent respectively of total expenditure, while payments of royalties and taxes to government—a category of value on which there is often greater focus—amounted to 3 per cent and 15 per cent respectively.

Any disruptions to these major streams of expenditure may have important repercussions: the shared-value paradigm, by promising to deliver benefits to host communities, regions and countries, has become increasingly critical for mining companies in securing their social licence to operate.¹ The delicate balance inherent in the shared-value paradigm is especially relevant for developing countries and other states where poverty eradication, social development and environmental protection are urgent development challenges.

The research question we ask in this paper is: *In the near and medium terms, what will happen to the local employment and procurement components of the shared-value paradigm—and, by extension, to the mining companies' social licence to operate—if technological change radically alters the amount of money mining firms are spending on hiring, procurement and other practices regarded as creating shared value?*

Technological Advances Driving Automation

Recent decades have seen ample productivity-increasing innovations at mine sites, such as larger, more durable and efficient shovels, haul trucks, crushers, grinding mills and flotation cells; and better chemistry to improve processing recoveries. In the long run, we will probably see technologies or practices that will radically change how mining is done, such as deep-sea mining, asteroid mining and microbe mining. Given the fundamental uncertainty and long-term nature of such technologies, we do not focus on them in this study, instead assessing new technologies that are being piloted today, which will be carried forward in the near-to-medium term. These technologies include:

1. *Autonomous haul trucks and loaders:* One person alone can already remotely operate a small fleet of these autonomous trucks. Improvements in software are likely to allow this to be performed even more efficiently by algorithm-driven computer programs. Driverless technology can lead to a 15 to 20 per cent increase in output, a 10 to 15 per cent decrease in fuel consumption and an 8 per cent decrease in maintenance costs.

¹ Social licence to operate is defined herein as a minimum and broad-based level of legitimacy, trust, acceptance and support of local stakeholders (including the host community, local leaders and civil society organizations) that a mining company requires for the operation of a mine.



2. *Autonomous long-distance haul trains*: Technologies are being piloted that allow long-haul trains carrying bulk commodities to run fully automated from the mine site to the port.
3. *Tele-remote ship-loaders*: Fitted with video cameras, thermal imagers, lasers and sensors, tele-remote ship-loaders are operated from a control room with a line-of-sight view. This type of automotive technology is unlikely to have an adverse net impact on employment, given that the operator is just moved from the cabin of the ship-loader to the control room, but the skill set changes.
4. *Semi-autonomous crushers, rock breakers and shovel swings*: These machines reduce the size of large rocks and scoop up the ore at the location of extraction. The mobile crusher performs two tasks simultaneously as it transfers the crushed rock directly for processing via conveyors, eliminating the need for haul trucks within a mine.
5. *Automated drilling and tunnel-boring systems*: These are used in open-pit mining and exploration activities. One operator can monitor up to five machines from a remote monitoring station. The remote operator needs only an interface with the machine to tell in what order the drill pattern should be drilled. The tunnel-boring machines significantly reduce the time, cost and risks involved to build and expand an underground mine. They are likely to halve the number of contractors involved in drilling and blasting, and those required during the construction phase.
6. *Automated long-wall plough and shearers*: This technology is being implemented in the coal mining sector. Before automation, workers manned the long-wall roof supports on hydraulic jacks, called shields. Similar to the automation of blast-hole drills, remote operation keeps workers out of harm's way near the drills and potential falling debris.
7. *Geographic information systems (GIS) and Global Positioning Systems*: GIS is now commonly used in almost all aspects of mining, from initial exploration to geological analysis, production, sustainability and regulatory compliance. Over time, however, as the use of GIS becomes more evenly dispersed on a global scale, old procedures for mine surveying will become redundant. Automated positioning systems can manage and improve the safe operation of heavy equipment such as dozers, drills, excavators, loaders, scrapers, graders, soil compactors, off road trucks and light vehicles.
8. *Autonomous equipment monitoring*: Using many different technologies, from cameras and thermal imaging to self-aware machinery able to report its progress, equipment monitoring is extremely important, as preventive maintenance workers can make up a large proportion of the workforce on a mine site.
9. *Programmable logic controllers (PLCs)*: Flexible PLCs are digital computers that typically automate industrial electromechanical processes and replace relays, timers, counters and sequencers. They are an enabling tool for improved process control. Once installed, they can be reprogrammed to improve the control of processes across the full spectrum of industry activity. This technology is the most crucial in the automation revolution and arguably the most important in taking away semi-skilled onsite jobs.
10. *Control systems*: Offsite control rooms are becoming bigger and more complex as mines become automated. Today, only mining companies with the most advanced technology have control systems that employ a substantial number of workers.

It is difficult to predict the speed at which these technologies will be rolled out, but the automation literature suggests that we are entering an era in which the availability of automation technology is accelerating rapidly. The technologies described above, all of which are in use now, are likely to reach their peak rates of deployment in the next 10 to 15 years. The commodity price downturn seems to have accelerated the move towards automation as companies are looking to increase mining productivity while reducing spending on staff, capital and energy.



Types of Occupations Most Affected and New Ones Created

New technology will change the nature of mining personnel tasks, whereby workers become passive supervisors of the process rather than active operators of equipment. Automation will reduce the number of operational jobs in areas such as drilling, blasting, and train and truck driving—areas that typically constitute over 70 per cent of employment in mines.

New roles will be created in the development, observation, servicing and maintenance of remotely controlled autonomous equipment as well in data processing and systems and process analysis. Consequently, workers with specialized skills in remotely controlled and automated systems will be in demand as automation increases, while current employees will need retraining, re-education or both to keep their jobs.

Results

There are many ways in which we might assess the impacts of a mining operation on its host community and host country, standard among which are:

- GDP, or gross value added: the amount of economic value the mining operation brings to the economy
- Employment: the number of jobs created by the mining operation
- Government revenues: the amount of revenue generated for the host governments by the mining operation.

We will use these three metrics in the analysis. Using expenditure data furnished by two companies and four mines—one located in a lower-middle-income country and three in a high-income Organisation for Economic Co-operation and Development (OECD) country²—we will estimate the magnitude of impacts to be expected in a typical mining operation.

This will necessarily be an imprecise exercise, and Appendix 1 lays out our assumptions and caveats. Ultimately our aim is to give the best possible indication of the magnitude of impacts to be expected, given the constraints.

The Baseline Cases

Both case study firms are mining entities, with some basic processing (concentration), and both have total annual expenditures exceeding USD 600 million.

The distinction between local and international procurement is worth noting.³ For the high-income OECD country mines, local procurement amounted to 58 per cent of total operational expenditures. The lower-middle-income country operation, by contrast, procured only 12 per cent of its goods and services within the host country.

The Impacts of Automation

While there is not enough research into the impacts of automation on the size of the mining workforce, we have two broad estimates on which to base our scenarios. McNab et al. (2013) suggest that introducing fully autonomous equipment “would reduce the workforce of a typical open-cut, iron-ore mine by approximately 30 to 40 per cent.” In another report, Accenture (2010) evaluates the economics of three types of equipment (trucks, dozers and drills),

² The companies involved have agreed to share procurement and other data with the researchers only on the condition that their names and commercially sensitive details be kept confidential.

³ In this paper we define *local* as sourced within the country of operations.



suggesting that automation could reduce the number of operators in open pit mines by up to 75 per cent. We build three scenarios of workforce reduction through automation, bracketing the two estimates cited above with rates of 30, 50 and 70 per cent. Doing so involves going through the detailed procurement accounts for each firm and deciding which would be sensitive to changes in workforce size.

Beyond the impacts of workforce reduction, we noted above that driverless technology using equipment under control (EUCs) will have impacts by saving on fuel consumption. Spence (2014) estimates that driverless technology can bring about a 10 to 15 per cent decrease in fuel consumption. We assume a 12.5 per cent decrease in diesel consumption in our scenarios. In addition, assuming that haul trucks in the mine are using EUCs and using the rate calculated by Fortescue in its iron mines in Australia, an extra 2.3 per cent in fuel savings could be achieved if they are installed in trucks (Australian Government, Department of Resources, Energy and Tourism, 2014). As such, we assume that mines could save 14.8 per cent in fuel used for hauling if they implement autonomous systems and EUCs. We also assume that 50 per cent of diesel in our sites is dedicated to hauling (a conservative estimate), and therefore subject to reduced demand under automation.

GDP Impacts

We combine the three scenarios (reductions in workforce of 30, 50 and 70 per cent) with savings of 14.8 per cent in fuel locally purchased. The highlights of the GDP impact results are:

- Impacts relative to total procurement are small: local procurement drops by 2, 3 and 4 per cent in the high-income OECD case, and in the lower-middle-income country case, the corresponding figures are 6, 9 and 11 per cent.
- Absolute impacts may be significant, particularly in the local communities: between USD 7.2 million and USD 15.8 million less spent in-country in the high-income OECD case, and between USD 4.6 million and USD 8.9 million less spent in the lower-middle-income country case.
- Worker-related procurement, such as housing expenditure, is the most significant element of the predicted reductions. Fuel savings are relatively small.

These results only cover a portion of the total impacts of mining automation, as they include neither the direct loss of wages and salaries for mine employees, nor the indirect and induced impacts of reduced spending.⁴ These elements are introduced in turn below.

Including salaries and benefits paid to mining workers in the analysis gives us:

- In the high-income OECD case, the mines' contribution to GDP in the three scenarios drops by between 9 and 20. The corresponding reductions for the lower-middle-income case are higher: from 13 to 31 per cent.
- While procurement drops in all three scenarios, the impacts of reduced payroll are much more significant. In the high-income OECD country case, reduction of wages and benefits are responsible for 86 per cent of impacts; and in the lower-middle-income country case, they are responsible for 92 per cent.

⁴ Indirect impacts result from the spending that suppliers must do to meet direct demand from the mining operation. Induced impacts are the result of consumer spending by employees of the mine.



When we add both indirect and induced effects to the analysis, we get the following results:

- An absolute reduction in contributions to the national economies of the host countries ranging from USD 92 million to USD 284 million.
- As a percentage of GDP in the respective host economies, this translates into small impacts: at most just exceeding 0.01 per cent in the high-income OECD. In the lower-middle-income country, the percentage is higher, ranging from just below 2 per cent to just below 4 per cent of national GDP.
- In terms of reductions to the overall value contributions made by the individual mining operations, the results are more significant: In the high-income OECD case, the percentage decrease ranges from 8.5 to 19.6 per cent, while the lower-middle-income country range is from 6.2 to 14.1 per cent.

Note that procurement and employment are not the only way that mining operations contribute to the well-being of their host communities, regions and countries. As discussed above, the shared-value paradigm also conceives of other important classes of spending—on infrastructure like roads that are shared by the general public, for example, or on downstream processing and beneficiation operations. It is not envisioned that automation will significantly affect these categories of spending.

Employment Impacts

Another way of assessing the impacts of mining expenditure is by measuring the number of jobs created.⁵ Direct employment in the high-income OECD country was 1,457 jobs, of which all were domestic. We estimate this number increases to 4,801 when indirect and induced effects are considered. In the lower middle-income country, the corresponding figures are 2,550 jobs, of which 2,470 are domestic, and 5,100 jobs if indirect effects are considered.⁶

These baseline case figures for jobs created can be modified using the three scenarios for job loss to get a picture of the types of impacts automation might have in terms of employment. Only direct and indirect effects are considered; if induced effects were included the numbers would be higher.

- Job loss in the high-income OECD country ranges from 1,016 to 2,372.
- Job loss in the lower middle-income country ranges from 1,530 to 3,570.

Government Revenue Impacts

The final category of impact is government revenue. This includes taxes, royalties and dividends paid by the firm to all levels of government in the host state. We also include, separately, estimated value of personal income tax paid by employees as a result of mine employment. We have assumed that the former will not change significantly as a result of automation, though that assumption is surely wrong: we expect automation to increase profitability, and corporate income tax and dividends are linked to profits. It would be difficult, however, to make any meaningful estimates as to their magnitude and nature, as they will depend so critically on the specific context of each operation.

In the baseline case, government revenues from payments made to government and personal income taxes of mine employees are twice as high in the lower-middle-income country case, driven by higher payments to government. Employee personal income tax rates are almost double in the high-income OECD case, and the average salary is twice as high, but that is not enough to mitigate the effect of the large difference in direct government payments; the latter are 4.5 times higher in the lower middle-income country case.

⁵ Employment is expressed in terms of full-time equivalent staff and does not count foreign head office employment or contractors.

⁶ We were unable to derive an estimate of induced employment effects, not having an appropriate employment multiplier.



The impacts of automation on the baseline cases, considering direct, indirect and induced effects:

- In the high-income OECD country, higher wages and higher personal income tax rates make the lost tax revenue much more significant, with a range of reduction from 25 to 58 per cent
- In the lower-middle-income country case, the corresponding reductions are much lower at 6 to 15 per cent.
- In absolute terms, the reduction in government revenues, including direct, indirect and induced personal income tax revenues, ranged from USD 7.6 million to USD 17.8 million in the lower-middle-income country case and from USD 31.7 million to USD 74.0 million in the high-income OECD country case.

Conclusions

Our analysis suggests that host countries will be increasingly at risk of reduced socioeconomic benefits from mining as existing new technologies are further rolled out. The impacts will be primarily in terms of lost local employment and personal income tax revenue, but will also come from reduced employment-related local procurement.

The significance of these impacts will vary from case to case. At first blush, several factors seem to indicate that the effects will be more significant in developed countries, since baseline local procurement is higher there, as are personal income taxes, and since labour-saving technologies will be more quickly deployed where wages are highest. That said, there are reasons to believe that developing countries will feel the impacts more strongly, since more of them are over-dependent on the extractives sector, since adapting to change demands financial and technical capacity that many developing country governments lack, and in light of the expected shift from low-skills to high-skills jobs. As well, even though wage levels are lower in developing countries, there still may be incentives to introduce labour-saving technology; reducing employment there may serve other objectives, such as addressing skills shortages or circumventing strong unions. Finally, it is likely that the mine of the future will involve decreased local equipment-related procurement, as new, more complex operating systems are imported and serviced under contract from abroad.

We noted that much of the social licence to operate may depend on the degree to which the shared-value proposition holds true. As such, the predicted drop in benefits derived from local procurement and employment should be a concern for firms and host countries and communities alike. It should also be a warning of the need for firms and governments to focus on other ways in which mining can contribute to the host economy and host communities.

Outside of the realms of procurement and employment, there are four other avenues through which shared value can be created:

1. *Downstream (forward) linkages* relate to the beneficiation of extracted commodities through refining, smelting and further downstream processing of the commodity before reaching the final consumer.
2. *Horizontal (lateral) linkages* relate to the development of new non-mining-related industries adapting the capabilities developed to serve the mining-related value chain.
3. *Knowledge (technological) linkages* relate to the transfer of knowledge and technological know-how to state-owned companies, the employees of the mine and to the labour force involved in the mine's value chain.
4. *Spatial (infrastructure) linkages* relate to the benefits associated with the infrastructure developed for an extractive-industry project (such as railways) profiting other actors in the economy.



The potential for each of these linkages is very context specific, and none is simple to realize. However, the trends surveyed above enhance the importance of assessing these alternative types of linkages.

There might also be efforts to revise the fiscal element of shared value. Most straightforward would be the passive receipt of the increased taxes, dividends and possibly royalties that should come from automation-driven improvements in productivity and profits. This may come in the form of higher tax levels on profits, or higher royalties on production.

There may also be options for governments that pursue newer approaches to managing the fiscal regimes in relation to mining by, in particular, adopting fiscal regimes that are more progressive with respect to prices, costs and time, and that tax away the rent as a resource rent tax would do.

Another set of options involves changes to the fundamental relationship between investor and host governments, with the latter considering new ownership structures ranging from, for example, increasing their equity share to maintaining full ownership of the resource and mining operation. These would imply more fundamental changes and alternatives to the prevalent concession agreement model, changes that have already been more common to the oil and gas sector. This could include forms of production-sharing agreements or fee-for-service contracts, for example. New combinations of changing ownership and contractual models may also arise. While none of the possibilities discussed here is straightforward, this set of options involves approaches with a record of successes and failures, and the lessons of history (both positive and negative) will be important for governments exploring these routes.

It is worth noting that government ownership of the resource would likely expand options for enhancing value in other parts of the shared-value paradigm, especially if linked with other government policies on training and local economic development. This would be subject to realistic appraisals of how to optimize value without putting at risk the value of the mining operation itself.

One clear lesson not explicit in the analysis above stems from the lack of readily available data on procurement. We found it exceedingly difficult to access data from companies on the kinds and volumes of goods and services they purchase at mine sites, for a host of reasons, despite good intentions on the part of a large number of firms. Similar projects and research the authors have engaged with have encountered similar challenges. Those problems go well beyond creating challenges for the present study. Not understanding what mining companies purchase locally has negative implications for corporate management, partnership building and government policy-making. A good starting point might be an effort by the industry to standardize the reporting in this area, if not for the sake of internal intelligence then in pursuit of ways to salvage the shared-value proposition.

There is clearly a need for further research in this area, both in confirming our basic findings and in exploring the nuances of the relationship we have identified. Does it matter, for example, if we are looking at open-pit or underground operations? Would different minerals yield significantly different results? It would also be interesting to explore more fully the relationship between the host country income level and the impacts of technology, both confirming the distinctions we observed and considering middle-income or emerging country cases; our two cases are situated toward the ends of the country income spectrum.

We expect that more research will sharpen our sense of what to expect as the advent of new technologies changes the way mining investment interacts with host countries, regions and communities. The better we understand the changing realities, the better both firms and host countries can ensure the continued relevance of the promise of shared value.



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1.0 INTRODUCTION





1.0 INTRODUCTION

The concept of shared value has become a linchpin of the modern mining sector. It has become a core concept to ensure that resource-rich countries gain the maximum benefit from the extraction of their resources, while ensuring that the private sector has a legitimate opportunity to extract the resources on a for-profit basis.

At its heart, the notion of shared value pertains to the sustainable development of the host state and host community. It involves issues of local procurement of goods and services, local employment, downstream uses of natural resources, uses of other resources surrounding the mine and mining community, and government revenue.

The delicate balance involved in the development of the shared-value paradigm, reviewed in more detail below (Section 2), is especially relevant for developing countries and other states where poverty eradication, social development and environmental protection are critical development challenges. The McKinsey Global Institute (2013) identified that in 2011 there were 81 resource-driven economies—where the mining and oil and gas sectors represent a significant part of GDP, exports and government revenue. The vast majority are developing countries, and almost 80 per cent have a per capita income below the global average. Roughly 69 per cent of the people living in extreme poverty in 2010—843 million people—were in resource-driven countries (McKinsey Global Institute, 2013). These figures illustrate the development challenges of resource-rich countries and explain the expectation that, through the application of the shared-value paradigm, the mining sector would bring substantial developmental benefits to large populations.

Beyond widespread endorsement and use by the industry, the shared-value paradigm has become ubiquitous in the literature and public discourse about mining and sustainable development. It has become a mainstay of major mining policy frameworks, such as the Africa Mining Vision (African Union, 2009), the Mining Policy Framework (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development [IGF], 2012) and the Organisation for Economic Co-operation and Development's (OECD) Framework on Public-Private Collaboration for in-Country Shared Value Creation from Extractive Projects (OECD, 2016). Industry organizations such as the International Council for Mining and Metals (ICMM) also reference the shared-value concept in their good practice guidance (see, for example, ICMM, 2015). Furthermore, leading civil society organizations working in the area of mining and sustainable development have fully subscribed to it (see, for example, Columbia Center on Sustainable Investment [CCSI], 2015; Wilson & Kuszewski, 2011, published by the International Institute for Environment and Development [IIED]; International Institute for Sustainable Development [IISD], 2014; Natural Resource Governance Institute [NRGI], 2015).

At the same time, the mining industry has been embarking on an unprecedented research and development program to vastly increase the use of high technology in the sector (as described in further detail in Section 3 below). This could lead mining companies to depend more on high-technology suppliers and skills that are only available in their home economies or in other more advanced economies; they would rely less on local labour, suppliers of goods and services, and other resources in the host community and state. Thus, technological improvements could drastically reduce the opportunities identified in the literature for mining companies to create shared value that supports the sustainable development of host communities and states, particularly through employment and procurement.



In this paper, we examine whether the local employment and procurement components of the shared-value paradigm will be able to survive the ongoing and expected technological improvements in the mining sector and, if so, how it may need to adapt so that high-technology mining companies may still be able to create shared value. Our analysis questions whether the paradigm is a viable policy framework for the future, or whether it is a strategy that would have worked in old-style labour-intensive mines but cannot work in new-style mines based on high technology and automation. Is the mining industry embarking on technological processes that will make the local employment and procurement components of the shared-value paradigm obsolete, causing the sustainable development benefits of the activity to disappear—like a mirage?

Specifically, the research question we ask is: In the near and medium terms, what will happen to the local employment and procurement components of the shared-value paradigm—and, by extension, to the mining companies' social licence to operate—if technology change radically alters the amount of money mining firms are spending on hiring, procurement and other practices regarded as creating shared value?

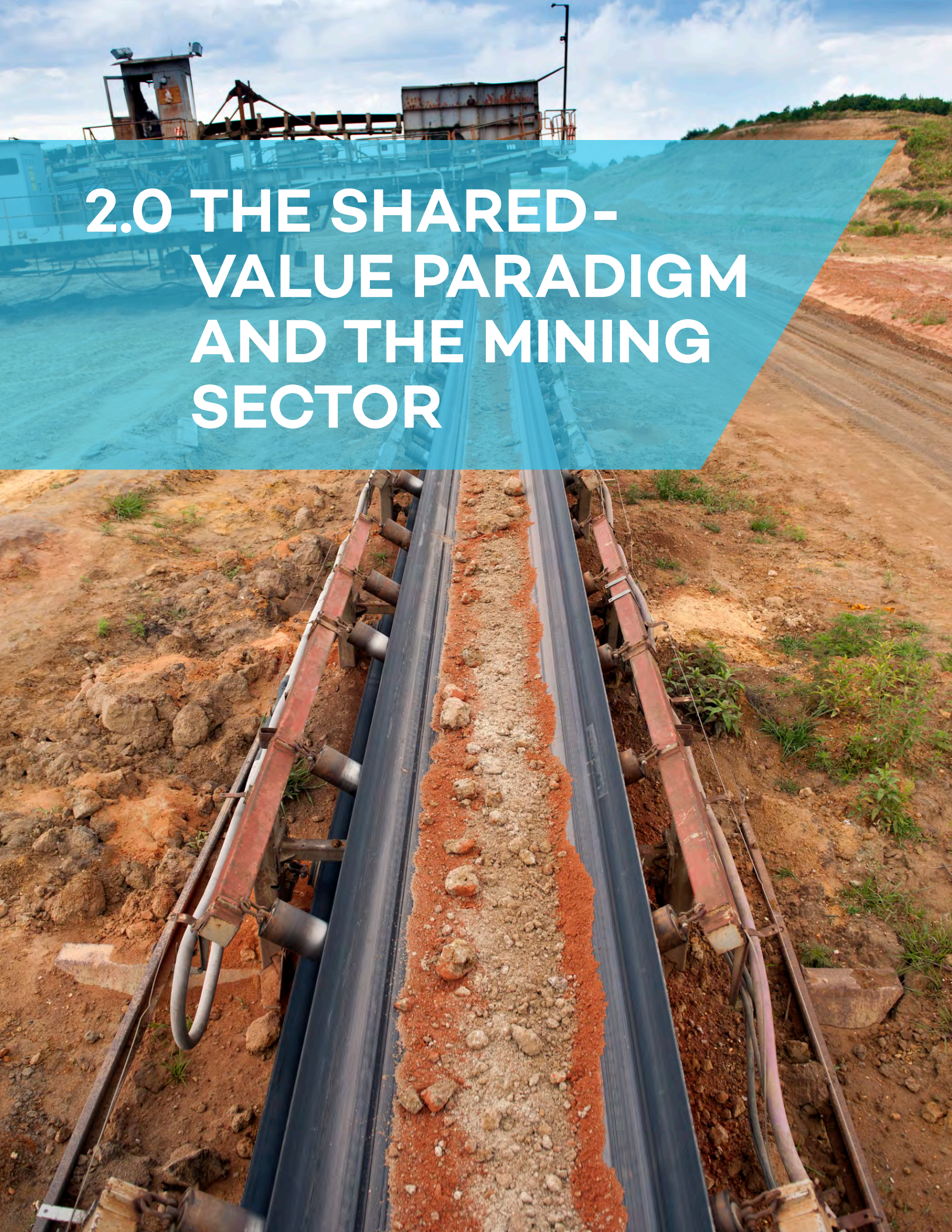
The issue is critical for all stakeholders:

- It is essential to local communities and generally to citizens of resource-rich countries, who expect their natural resources to generate value that supports their development objectives.
- Mining companies must consider whether and how they contribute meaningfully to addressing societal concerns—much beyond the goal of generating profits for their shareholders—as a requirement to earn and keep their social licence to operate.⁷
- Civil society organizations may need to reassess their level of commitment to the local employment and procurement components of the shared-value paradigm, asking whether they have become complicit in endorsing a paradigm that in the future will be unable to deliver as promised.
- It is also important to governments at the local and national levels, as they formulate and implement policies: if technological change significantly affects the shared-value paradigm, does this imply the need to change policies such as performance requirements, whose success is based on exploiting the gains from an increasingly smaller source?

In this paper, we explore these issues by first examining the shared-value paradigm and its application to the mining sector (Section 2). We then assess the impending technology changes in the mining sector (Section 3) and consider their implications on local employment and procurement, critical components of the shared-value paradigm. Our analysis, laid out in Section 4, suggests that these implications will be towards significant downward trends in numbers of employees, and less opportunity for local procurement of good and services. Given this result, we turn to some options that governments and industry ought to consider (Section 5), whether separately or in partnership, to address what we see as the likely impacts of seeking to implement technological improvements in a shared-value paradigm. Appendix A lays out the assumptions we made and caveats necessary in view of the difficulties we encountered in obtaining relevant data—a challenge facing researchers as well as policy-makers who aim to study the impacts of technological shifts and other significant changes at the macro-level.

⁷ Social licence to operate is defined below as a minimum and broad-based level of legitimacy, trust, acceptance and support of local stakeholders (including the host community, local leaders and civil society organizations) that a mining company requires for the operation of a mine.





2.0 THE SHARED- VALUE PARADIGM AND THE MINING SECTOR



2.0 THE SHARED-VALUE PARADIGM AND THE MINING SECTOR

Shared value goes beyond companies focusing on community investment and philanthropy approaches, and argues that firms can bring value to both themselves and their host communities, regions and countries through enhanced local procurement of goods and services, local employment, downstream uses of natural resources, uses of other resources surrounding the mine and mining community, and government revenue.

2.1 From Corporate Social Responsibility (CSR) to Creating Shared Value (CSV)

Companies have long attempted to use community investment and philanthropy to create benefits for the societies in which they operate. In many cases, these initiatives have arisen in response to external pressure to make companies responsible for correcting the failures resulting from economic activities conducted to the detriment of the society's broader economic, social and environmental concerns.

Porter and Kramer (2006, 2011) propose going beyond philanthropic approaches unrelated to the firm's core business rationale and activity. The authors (2006, p. 84) first suggest a so-called "strategic corporate social responsibility" (CSR) framework, introducing the concept of shared value—"a meaningful benefit for society that is also valuable to the business." Later they develop the concept further, proposing creating shared value (CSV) as a paradigm intended to supersede what they see as the narrow business logic of profit maximization and CSR, as they define it⁸:

The concept of shared value can be defined as policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates. Shared value creation focuses on identifying and expanding the connections between societal and economic progress. (Porter & Kramer, 2011, p. 6)

The shared-value paradigm recognizes that the factors of successful long-term business performance include not only financial aspects, but also consumer and societal needs, community concerns, environmental sustainability and well-functioning supply chains, among other elements. It considers that markets are defined by societal needs just as well as by conventional economic needs. According to the authors, if businesses take decisions based on the shared-value paradigm, they can generate innovation and growth for the benefit of companies and society in an integrated manner (Porter & Kramer, 2011).

⁸ In their work Porter and Kramer (2011) define CSR as consisting of philanthropic approaches including donations and community investment. However, several commentators (see, for example, Crane, Palazzo, Spence & Matten, 2014) argue that their portrayal of CSR in this way is an intentional "straw man" definition that narrows it to these philanthropic approaches and point out that most other definitions include general corporate behaviour and ethics.



More specifically, Porter and Kramer (2011, p. 7) indicate that shared value can be created through business activity under three categories of opportunities: “by reconceiving products and markets, redefining productivity in the value chain, and building supportive industry clusters at the company’s locations.”

To create shared value by reconceiving products and markets, companies should constantly look at the needs, benefits and harms embodied in their products, and explore opportunities for market innovation, repositioning and expansion. For example, reaching underserved markets (consumers in poor and disadvantaged communities, in both developing and developed countries) could generate large societal benefits and substantial company profits (Porter and Kramer, 2011).

Redefining productivity in the value chain, the second category of shared-value creation, can be done through improvements in logistics and in the use of energy and other resources (water, raw materials, packaging). Adopting better technologies, reducing or rationalizing the use of resources and promoting recycling practices can create shared value across the value chain. Companies can also help develop marginalized suppliers—through providing access to inputs, technology and financing—thus encouraging them to improve their quality and guaranteeing growing volume of supply. Porter and Kramer (2011) offer examples of shared-value creation through rethinking procurement strategies, distribution practices, employee productivity incentives and locational choices.

The third way to create shared value, according to Porter and Kramer (2011), is to enable the development of local clusters, in view of the recognition that a company’s performance depends on the surrounding infrastructure and supporting companies. To help develop clusters, the companies should try to identify local gaps in areas including infrastructure, suppliers and educational institutions; consider which areas represent the greatest constraint to the company; and assess where the company may create shared value by direct influence or in collaboration with other actors.

Criticized by few (Beschorner, 2014; Crane, Palazzo, Spence & Matten, 2014; Hartman & Werhane, 2013), the shared-value proposition gained broad endorsement in the literature as an important development in business management (see, for example, Ajith, 2014; Atiq & Karatas-Ozkan, 2013; Palmer, 2012; Pfitzer, Bockstette & Stamp, 2013; Pharoah & Walker, 2015; Solís & Moroka, 2011).

In this paper, when we refer to shared value, we mean opportunities to align society’s interests with core business objectives and expertise. We do not, however, presume that such opportunities exist in all cases, or that shared value can in all cases obviate the need for the philanthropic version of CSR (Geipel, 2015).

2.2 Making the Shared-Value Paradigm Work in the Mining Sector

The categories indicated by Porter and Kramer (2011) for creating shared value translate into tangible opportunities for mining companies. They can create shared value in their activities by conducting local procurement of goods and services and supporting the development of local suppliers; creating local employment; developing local skills through education and training; building or improving local infrastructure and logistics networks; supporting local enterprises for downstream uses of natural resources; and ensuring stable sources of tax and royalty revenues for governments (Dodd, Jakobsen, Dietsche & Macdonald, 2015; Hidalgo, Peterson, Smith, & Foley, 2014).

The literature and the mining industry itself increasingly recognize that mining companies must obtain and maintain the so-called social licence to operate (Mann, 2015). The concept, difficult to define and still evolving, can be understood as the minimum and broad-based level of legitimacy, trust, acceptance and support of local stakeholders (including the host community, local leaders and civil society organizations) that a mining company requires for the operation of a mine (Mann, 2015; Dodd et al., 2015).



By enabling mining companies to use their activities and resources to contribute meaningfully to the sustainable development of host communities, the shared-value paradigm became key for mining companies to secure their social licence to operate. Many mining companies have endorsed the paradigm, embracing it as a chance to regain the trust they had lost as communities increasingly blamed their activities for economic, social and environmental problems. The literature provides a wealth of examples of how mining firms can engage and have engaged in creating shared value through their activities (see, for example, Bastida, 2014; Hidalgo et al, 2014; Hope & Kwarteng, 2014; Svensson & Barnard, 2015).

Figure 1 illustrates the importance of a broad understanding of how the mining sector can contribute to the well-being of local communities and host states. If we take these expenditures as, in rough measure, typical of a large mine, we see the importance of moving beyond the traditional focus on direct government revenues—taxes and royalties—to capturing a significant part of the supplies and services expenditures of a mine operation.

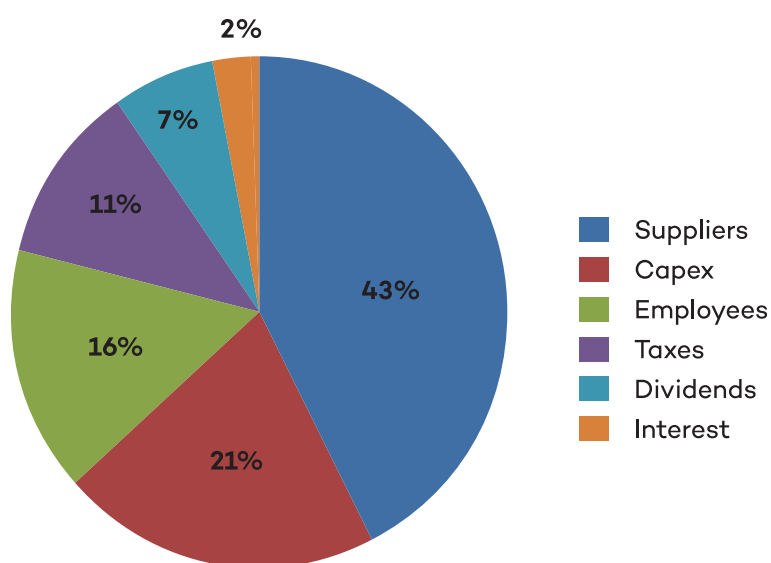


Figure 1. Anglo American Expenditures 2014

Source: Anglo American plc (2014)

In this case, we see that total expenditures on taxes and royalties are at about 11 per cent of total expenditures by the company.

A second traditional focus of governments for revenues has been dividends. Here, we see about 7 per cent of total expenditures, but these are dividends for all shareholders, not just for government. If we assume for the sake of illustration that governments have a 15 per cent equity stake, then about 1 per cent of the total expenditure goes back to government from dividend spending. And unless government representatives control 50 per cent of the board of directors, the allocation of any dividends generally remains an issue fully within the control of the investor itself.

In the case of both taxes and dividends, the percentages pale in comparison to the labour and purchasing components, at 15 and 43 per cent of company expenditures, 58 per cent when combined. For shared value to have a really significant meaning (in the context of employment and procurement), significant proportions of these two parts of the pie must accrue to the host state.



In addition to their direct benefits to the local community and national manufacturing sector, the multiplier effects of these components are the most important of the economic spin-offs from mining. Procurement of goods and services from local suppliers strengthens local manufacturers and service providers, enabling them to maintain and progressively increase re-investment, employment opportunities and wages. In the best of cases, those suppliers become globally competitive exporters of their products. As consumers, the employees of these local suppliers also spend their wages in the local economy, thus helping stimulate the maintenance and development of other economic sectors. Taxes on local goods and services and on the income of local employees help ensure and progressively increase government revenues, which can in turn revert in favour of the local communities in the form of social policies, infrastructure and public services, among others.



3.0 TECHNOLOGICAL ADVANCES DRIVING AUTOMATION





3.0 TECHNOLOGICAL ADVANCES DRIVING AUTOMATION

3.1 Scope, Scale and Timing

Mining productivity has increased over the years (Figure 2). While recent decades have seen a lot of innovation to increase productivity at mine sites (such as larger, more durable and efficient shovels, haul trucks, crushers, grinding mills and flotation cells, and better chemistry to improve processing recoveries), automation is expected to rapidly increase productivity between 7,000 and 8,000 tons/person-year.

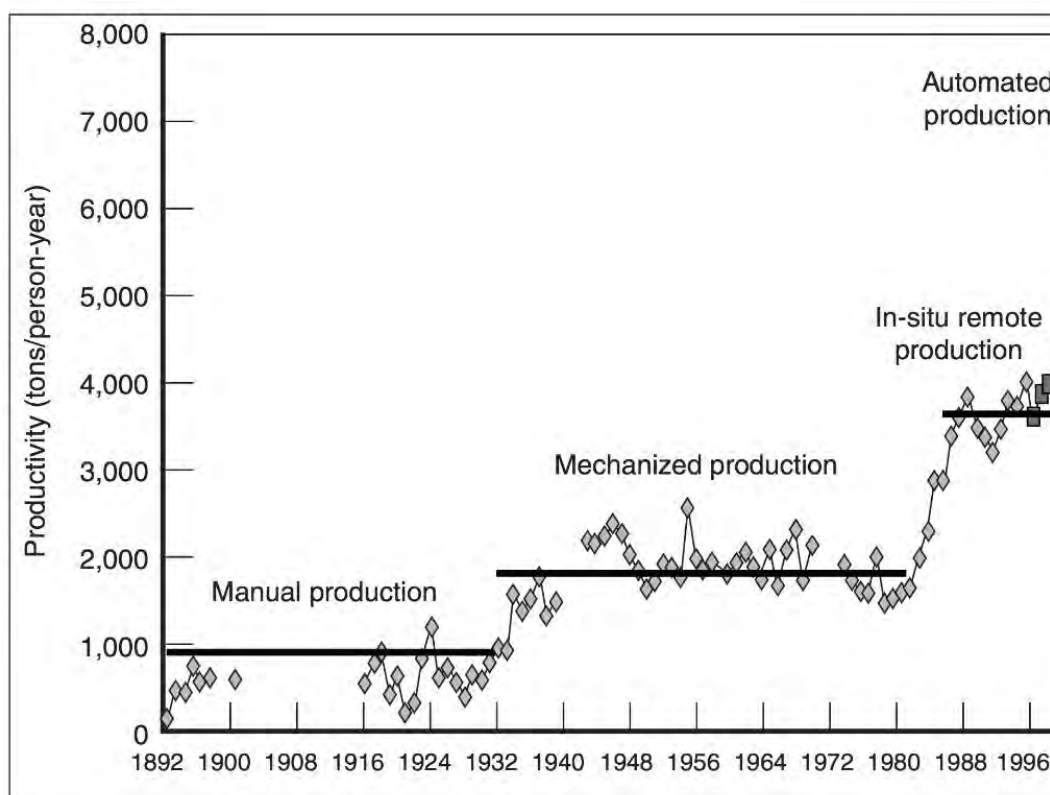


Figure 2. Past productivity and anticipated productivity from technology change

Source: Peterson, LaTourrette & Bartis (2001, p. 49). Image reproduced with permission from Rand Corporation.

The mine of the future may implement technologies or practices that will fundamentally change how mining is done, such as deep-sea mining, asteroid mining and microbe mining. Given the fundamental uncertainty and long-term nature of such technologies, we do not focus on them, instead assessing the technologies that are being piloted today, which will be carried forward and drive automation in the near-to-medium term (IBM, 2009).

These technologies can be sub-divided into three categories:

- a) *Tele-operations* refer to mining vehicles controlled by an operator at a remote location with the use of cameras, sensors and possibly additional positioning software. Joysticks or other handheld controls are still used to control the vehicle's functions, and operators have greater access to vehicle telemetry and positioning data through the tele-operation software.



- b) *Semi-automation* refers to partly automated control of mining machines. Only some of the functions are automated, and operator intervention is needed. Remote control technology is generally used to enable mining equipment to operate in dangerous conditions such as unstable terrain, blast areas, high-risk areas of falling debris and underground mining.
- c) *Full automation* refers to the autonomous control of one or more mining vehicles. Robotic components manage all critical vehicle functions, including ignition, steering, transmission, acceleration and braking, and implement control (that is, blade control, dump bed control, excavator bucket and boom, etc.) without the need for operator intervention.

This sub-categorization is of interest, because tele-operations are unlikely to lead to a fall in workforce, but rather require a different skillset by the operators. Semi-automation and full automation, on the other hand, will not only require a different skillset by the operators, but also reduce the number of workers required to operate the mine. All these categories will require sourcing technologically more advanced goods and services. It should be noted though that in many instances technological advances go through all these three categories starting off with tele-operations, moving to semi-automation and ultimately to full automation.

Below we present the key technologies being piloted that are currently driving the automation process. Apart from highlighting the current state of these technologies and likely development going forward, we also discuss the probable impact on employment resulting from these technological advances.

1. *Autonomous haul trucks and loaders*: The most publicized of all the mining automation technologies are driverless haul trucks. One person alone can already operate remotely at one time a small fleet of these autonomous trucks. Improvements in software are likely to allow this to be performed even more efficiently by algorithm-driven computer programs. By allowing a fleet of haul trucks to run autonomously, the safety, maintenance requirements, efficiency and environmental concerns of a mine site can be improved. According to researchers from the University of British Columbia, driverless technology can lead to a 15–20 per cent increase in output, a 10–15 per cent decrease in fuel consumption and an 8 per cent decrease in maintenance costs (Spence, 2014). Rio Tinto announced that the “effective utilization” of autonomous trucks in the Hope Downs 4 iron ore mine was 14 per cent more productive “than in the best human-staffed mine in the Pilbara” (Ker, 2015), and 13 per cent less expensive in terms of load and hauling costs (Rio Tinto, 2014). Rio Tinto’s Pilbara mine is the poster child for driverless haul trucks. To develop its autonomous trucks, Rio Tinto collaborates with Komatsu Ltd, a Japanese corporation that manufactures construction and mining equipment. The other company whose mines have incorporated driverless haul trucks is BHP Billiton, which has been working with Caterpillar since 2007 to produce autonomous driver technology (Ker, 2015). Beyond Australia, Sandvik, a supplier of equipment for mines has developed Sandvik Automine, which is an automated loading and hauling system for underground hard-rock mining. It has been used at a Codelco mine in Chile (since June 2004), a mine in Finland (since January 2005), a mine in South Africa (since August 2005) and a mine in Canada (since June 2007). Atlas CopCo, another supplier of mining equipment, has also tested remote haulage zones with two fully automated trucks at Nordana’s Brunswick ore mine in Quebec, Canada (Horberry & Lynas, 2012).

Haul truck automation currently appears to have the greatest direct impact on mine employment. The technology has seen greater implementation than the other ones mentioned below, and truck drivers comprise a large portion of the workforce on the average mine site. Automating the haulage process by letting computer algorithms control the trucks nullifies the need for the haul truck drivers. Only a few job openings can be expected as a result of full truck haulage automation (more jobs in the semi-automation



stage when operators control a small fleet of trucks). These operator jobs will require a different skillset from those of the truck drivers.

2. *Autonomous long-distance haul trains*: Technologies are being piloted that allow long-haul trains carrying bulk commodities to run fully automated from the mine site to the port. Rio Tinto has designed a fully automated train network for its iron ore mines in Western Australia's Pilbara region. At the time, the project was estimated to cost USD 518 million. The company stated that automated trains would help address a significant skills shortage facing the industry while improving productivity at its iron ore operations (Ker, 2015). Rio Tinto planned to have 41 trains hauling its iron ore. With three high-paid drivers per train being nullified by automation, along with additional operators and staff who keep these trains running, the company announced that up to 500 employees could lose their jobs (Taylor, 2012).
3. *Tele-remote ship-loaders*: Fitted with video cameras, thermal imagers, lasers and sensors, tele-remote ship-loaders are operated from a control room with a line-of-sight view. Rio Tinto is implementing the technology at Dampier port (Mills, 2010). This is an example of the type of automotive technology that is unlikely to have an adverse impact on employment, given that the operator is just moved from the cabin of the ship-loader to the control room.
4. *Semi-autonomous crushers, rock breakers and shovel swings*: These are machines designed to reduce the size of large rocks and scoop up the ore at the location of extraction. The mobile crusher performs two tasks simultaneously as it transfers the crushed rock directly for processing via conveyors, eliminating the need for haul trucks within a mine. The mobile crusher was, for instance, implemented at Peppertree Quarry in New South Wales, Australia (Process Online, 2013). Semi- and fully autonomous shovel swing loading systems have been tested and implemented in Australia.
5. *Automated drilling and tunnel-boring systems*: Automatic drilling machines are used in open-pit mining and exploration activities. One operator can monitor up to five machines from a remote monitoring station. The remote operator needs only an interface with the machine to tell in what order the drill pattern should be drilled (Fiscor, 2009). Atlas CopCo has tested fully automated surface drilling technology at the Rocktec Application Centre in Perth, Western Australia (Horberry & Lynas, 2012). The tunnel-boring machines can significantly reduce the time and associated cost to build and expand an underground mine while doing it safely. Atlas Copco's modular boring machines have achieved more than 10 metres a day, which is almost twice the rate achieved by conventional methods (Mining-technology.com, 2014). The technology is likely to reduce by half the number of contractors involved in drilling and blasting and required during the construction phase.
6. *Automated long-wall plough and shearers*: This technology is being implemented in the coal mining sector. Before automation, workers manned the long-wall roof supports on hydraulic jacks, called shields. Similar to the automation of blast-hole drills, remote operation keeps workers out of harm's way near the drills and potential falling debris. While increasing workers' health and safety, this process has reduced the number of workers in underground coal mines since the 1990s. The more recent technologies require less manual support, and these technologies have improved productivity by up to 10 per cent (CSIRO, 2015).
7. *Geographic information systems (GIS) and Global Positioning Systems (GPS)*: Geospatial professionals with engineering and design firms have long had a traditional role in pre-mining stages of surveying, exploration, land rights management, environmental impact assessment and construction. GIS is now commonly used in almost all aspects of mining, from initial exploration to geological analysis, production, sustainability and regulatory compliance. Over time, however, as the use of GIS becomes more evenly dispersed on a global scale, old procedures for mine surveying will become redundant. Automated positioning systems



have produced GPS technology and location-based services “to manage and improve the safe operation of a wide range of earthmoving and heavy mobile equipment from single machines to entire fleets including dozers, drills, excavators, loaders, scrapers, graders, soil compactors, off road trucks and light vehicles” (Horberry & Lynas, 2012, Appendix 1, p. 5). These systems have been implemented in Australia at the North Curragh and Cloudbreak mines (International Mining, 2012; Wirtgen, 2011). GPS and equipment sensors combined with wireless communication technology can be used as a “passive” collision avoidance system (Horberry & Lynas, 2012).

8. *Autonomous equipment monitoring*: The technology is integrated in most new mining equipment. Using many different technologies, from cameras and thermal imaging to self-aware machinery able to report its progress, equipment monitoring has an important role in optimizing mining (Fischer & Schnittger, 2012). This is a very broad category of automation, but is extremely important, as preventive maintenance workers can make up a large proportion of the workforce on a mine site. With this technology, predictive maintenance replaces preventive maintenance (Maras, 2013).
9. *Programmable logic controllers (PLCs)*: Flexible PLCs are digital computers that typically automate industrial electromechanical processes and replace relays, timers, counters and sequencers. PLCs are an enabling tool for improved process control. Once installed, they can be reprogrammed to improve the control of processes across the full spectrum of industry activity. Therefore, their flexibility enables an organic growth of automation capability (Horberry & Lynas, 2012). Above all other technological advancements, this is the most crucial in the automation revolution and arguably the most prevalent in taking away semi-skilled onsite jobs.
10. *Control systems*: Offsite control rooms are becoming bigger and more complex as mines become automated. Today, only mining companies with the most advanced technology, such as Rio Tinto, have a control system that employs a substantial number of workers (Lynas & Horberry, 2011).

Based on the literature reviewed, Figure 3 plots each of the above technologies—identified by its respective number—along a horizontal timescale and a vertical scale of employment impact.

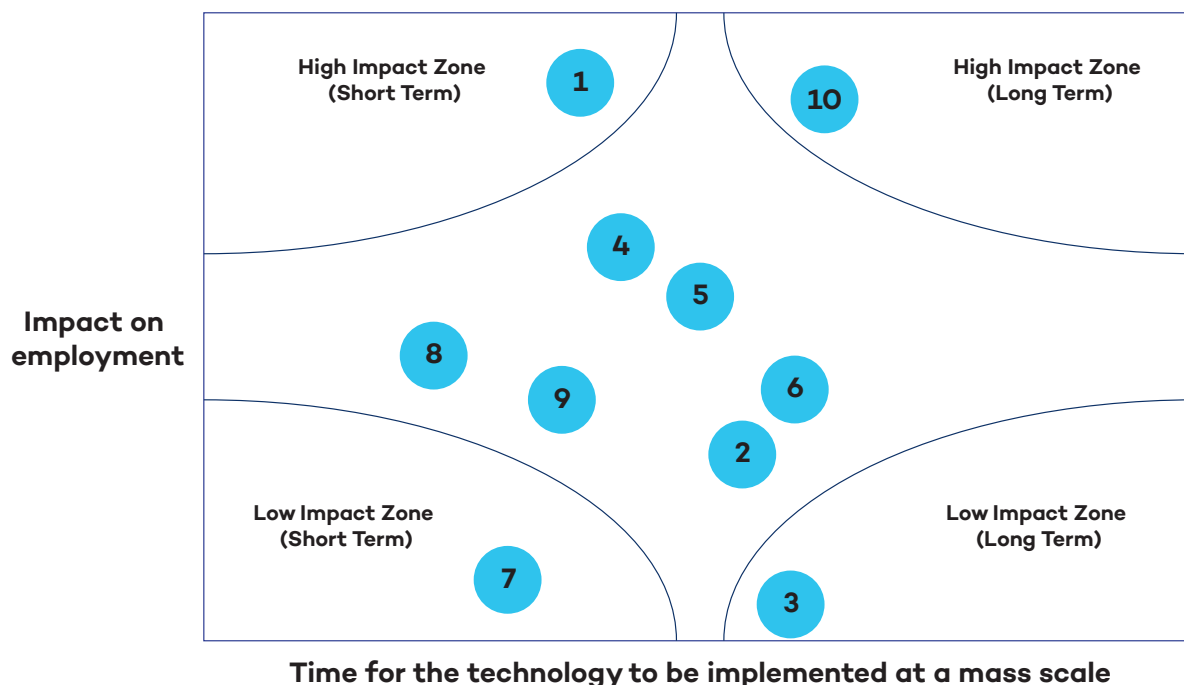


Figure 3: Estimated relative impact of technological changes and impact on employment

Source: The authors

The automation of haul trucks (1) will have a high impact on employment in a relatively short term, given that existing mines have been testing these technologies successfully and have benefitted from a large fall in operating costs. GIS and GPS technologies (7) are already being rolled out in most mine sites, but these improvements are unlikely to have a large impact on employment. The rolling out of automated ship-loaders (3) is likely to take longer, given that the technology is still in its infancy, and tele-operations that are implemented are unlikely to have a drastic impact on employment. Considering that the increasing adoption of highly advanced control systems (10) will depend on the rolling out of all other automation technologies, it is likely that these will take time to be common among mine sites. Moving in-pit staff into control centres will have a significant impact on employment.

The speed at which these technologies are going to be rolled out is difficult to predict, but the automation literature suggests that we are entering an era in which the availability of automation technology is accelerating rapidly. Currently in Australia, automation is engaged on a small scale relative to the existing number of mines, processing plants and export facilities. There are close to 500 sites associated with the resource industry. While some may be engaging in automation, only a handful of pioneering trials can claim automation as an operational concern. The commodity price downturn seems to have accelerated the move towards automation as companies are looking to increase mining productivity while reducing spending on staff, capital and energy (Deloitte, 2015). As indicated in the research performed by the Mining Industry Skills Center Inc. (2010), the strongest growth in automation is anticipated to take place over the next decade. The movement of all sites toward automation is foreseeable, and the rate of uptake is likely to be greatest over the next 15 years. The bell curve in Figure 4 demonstrates the expected progression in the amount of uptake of automation over the next 20 years in the Australian mining industry.

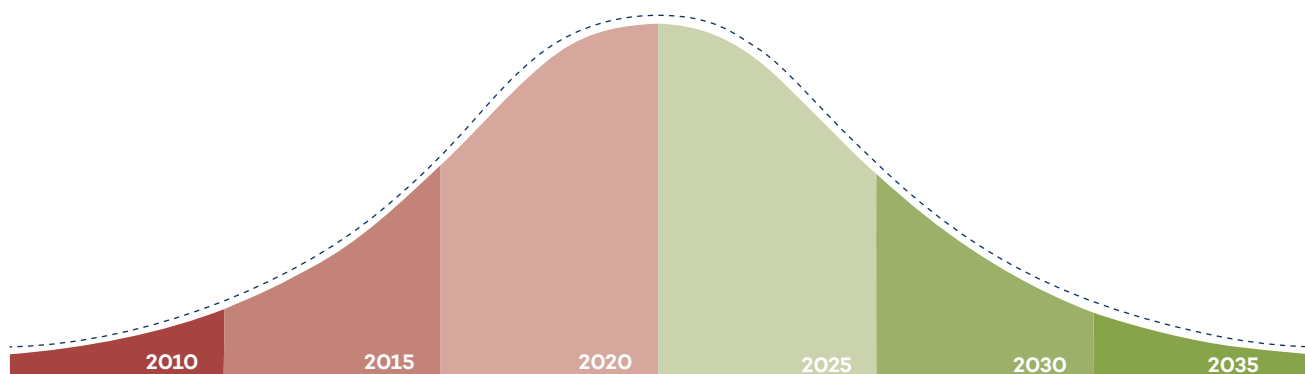


Figure 4. Expected automation in the mining industry, Australia, 2010–2035

Source: Mining Industry Skills Center Inc. (2010)

3.2 Types of Occupations Most Affected and New Ones Created

New technology is almost certain to change the nature of mining personnel tasks whereby the human often becomes more of a passive supervisor of the process rather than an active operator of equipment. Automation will reduce the number of operational jobs in areas such as drilling, blasting, and train and truck driving—areas that constitute a high proportion of the mining workers, as can be seen in Figure 5.

New roles will be created in the development, observation, servicing and maintenance of remotely controlled autonomous equipment as well in data processing and systems and process analysis. Other traditional roles will however remain, relating to site rehabilitation, road building and other site works in particular (McNab et al., 2013). Consequently, workers with specialized skills in remotely controlled and automated systems will be in demand as automation increases, while current employees will need retraining, re-education or both to keep their jobs (Somarin, 2014). Those specialized skills rely on knowledge of mathematics and science and an ability to use information technologies (McNab et al., 2013).

All in all, some studies anticipate that, as a result of this revolution, “autonomous technologies seem likely to reduce additional jobs created through mining industry growth, rather than leading to a net reduction in mining employment” (McNab et al., 2013)

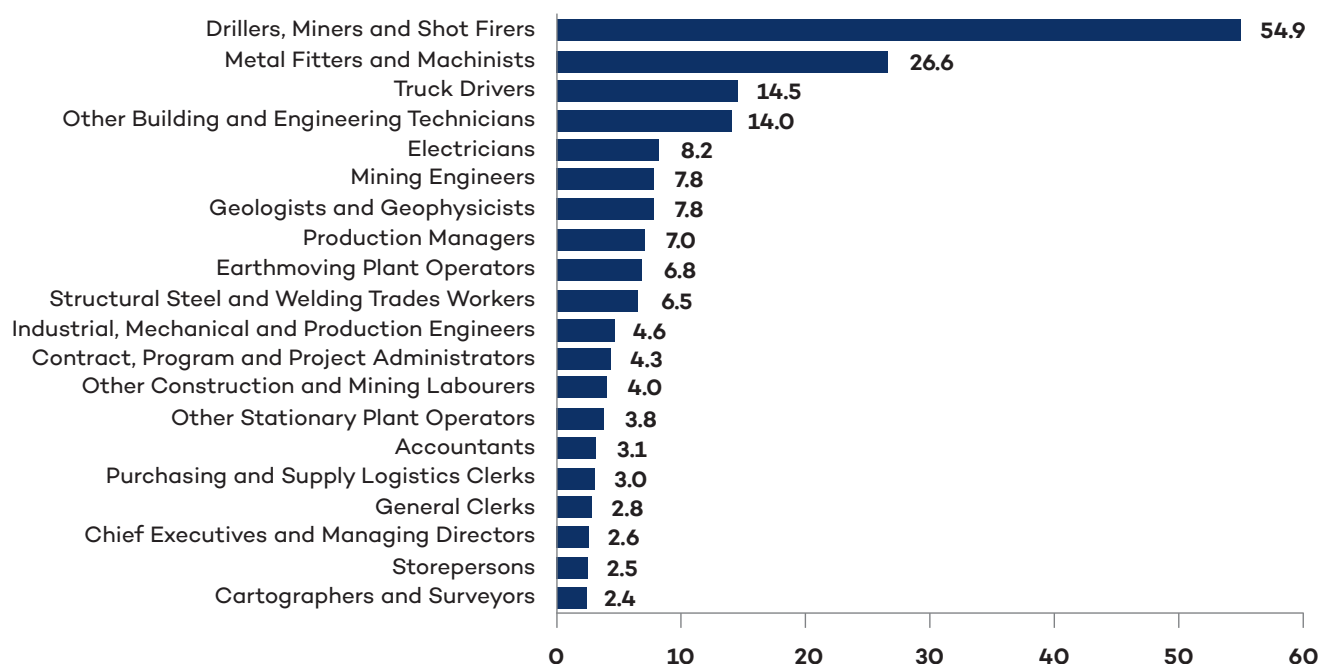


Figure 5. Main employing occupations in the mining industry (x 1,000)

Source: Australian Government, Department of Employment (2014)

3.3 Expected Impacts in Developing and Developed Countries

The impact of automation might be felt differently between developing and developed countries if we consider a series of factors working in opposite directions.

The first factor is the cost of labour. We can assume that mining companies are more motivated to save on employment in areas where the labour is more costly and salaries are higher. For this reason, Australia and Canada's workforces could be more threatened by automation than those in developing countries.

The second factor is the search for higher safety, which is a unanimously accepted benefit of automation. "Reducing the numbers of people involved on the field mechanically reduces the probability of having accidents, especially considering that the mining industry will extract commodities from deeper and more complex ores in the future" (Mining Global, 2014). This factor would have disparate impacts if there were significant country-level differences between worker safety laws and regulations.

A third factor is driven by the shortage of skilled labour in some countries. Some in the industry have described automation as a partial solution to the perennial problem of skills shortages: "By providing a safer working environment, the mining industry might be able to tackle the current labor shortage and attract high potential profiles" (Mining Global 2014). This might point toward developing countries being at a higher risk of witnessing automation roll-out than developed countries, given that the skills shortages there tend to be more acute.

The fourth factor is the country's capacity to deploy policy instruments to mitigate unemployment resulting from automation. These policy instruments range from training programs and tax credits to incentives that support self-employment. Figure 6 features a range of policy instruments on which the institutional investors of CitiBank were surveyed; investment in education, support to self-employment, active labour policies and funding for research



appear as the policies having the most successful impacts in mitigating the negative impact of automation on labour, irrespective of the sector. These policy instruments are expensive to implement and their infrequency in developing countries affected by automation might reinforce the differentiated impact between developing and developed countries (Frey & Osborne, 2016).

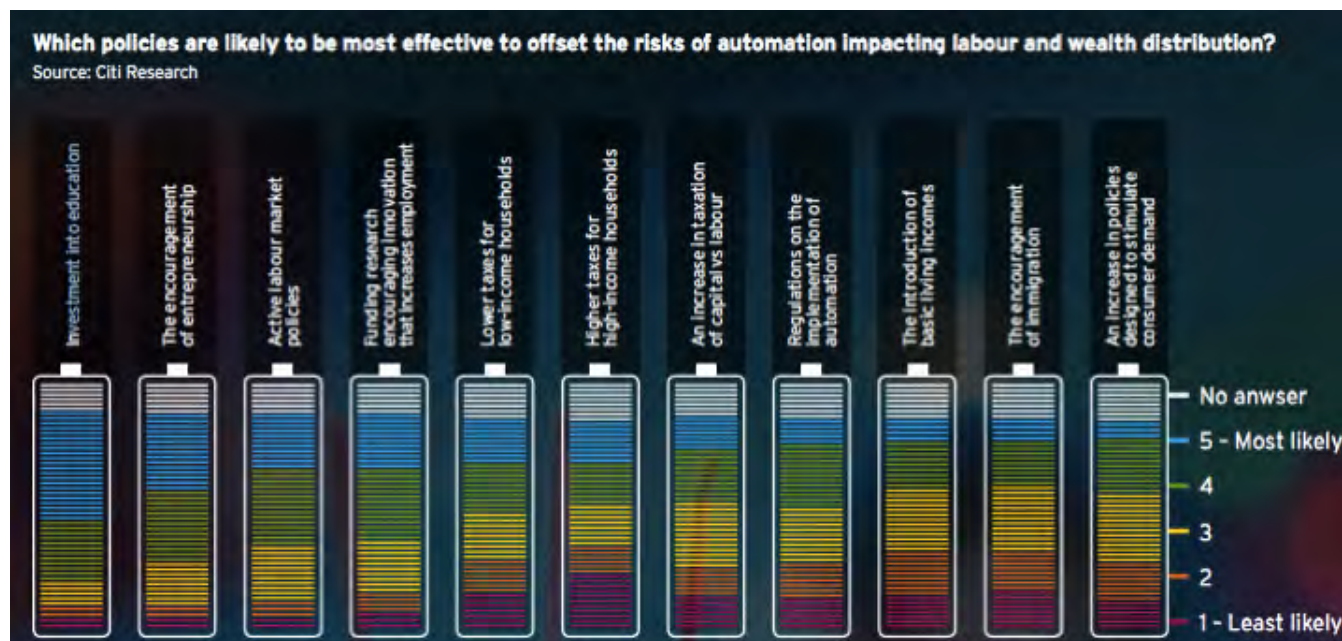


Figure 6. Policies likely to be most effective in offsetting the risks of automation impacting labour and wealth distribution

Source: Image reproduced with the permission of Citi GPS (2016).

The fifth factor relates to workforce acceptance, materialized in particular by the unions' resistance. This is, of course, not new: in the 20th century, labour unions resisted production technology in mining, shipbuilding, car-making and cotton weaving. The responsibility for the declining technological dynamism of post-Victorian Britain is often attributed to the growth of the labour movement's power. In the 1930s, Indian trade unions resisted a technical and administrative rationalization of cotton mill practices, which made India lose its market share. In the European and American auto industry, unions have opposed the closing of out-dated plants and the introduction of efficient practices of Japanese car manufacturers. Not all unions are conservative, and those in Germany and Sweden have historically shown more support to technology progress than elsewhere (Mokyr, 1997). Developing countries also boast strong unions, as the 2012 riots at South African mining sites highlighted, so it is unclear whether higher social and political resistance will occur in developing or developed countries. While it may be harder to implement job cuts in places where trade unions are stronger, there is a larger incentive for mining companies that develop new projects to implement new technologies that minimize labour at their mine site in order to have more control over operations.

There are, of course, many ways in which automation and other new technologies will affect developing and developed countries alike. This is the case, for example, when automation is deployed not only to replace current tasks but also to enable "operations to reach mineral deposits that cannot be economically extracted under existing methods and mine layouts" (Anglo American, 2013).



4.0 RESULTS





4.0 RESULTS

The research question pursued in this project is: What are the impacts of mining operations on local and national host economies if current trends in automation continue? In the previous section, we surveyed the changes in technology that we can reasonably foresee for the mining industry. Of those, we noted several with potential to alter the level of local spending in the operational phase of mines.

There are many ways in which we might assess the impacts of a mining operation on its host community and host country, standard among which are:

- GDP, or gross value added: the amount of economic value the mining operation brings to the economy
- Employment: the number of jobs created by the mining operation
- Government revenues: the amount of revenue generated for the host governments by the mining operation

In what follows, we will use these standard metrics to estimate the impacts of automation. Using expenditure data from two companies and four mines—one located in a lower-middle-income country and three in a high-income OECD country⁹—we will indicate the magnitude of impacts to be expected in a typical mining operation.

This will necessarily be an imprecise exercise. First, our sample size is small (we discuss in Section 6.1 the difficulties in obtaining data). Second, the nature of the technological advances driving changed impacts is unknown, and we will need to make reasonable assumptions based on the technology survey presented in Section 3. Third, even if future technological developments were fully known, the impacts of those developments on any individual mining operation would be a function of many context-specific factors, among them: the income level of host country, the type and scale of operation and the mineral or metal mined. We discuss these caveats more fully below, and give a detailed description of methodology and assumptions in Appendix 1. Ultimately, our aim is to give the best possible indication of the magnitude of impacts to be expected, given all the significant constraints on precise calculation.

4.1 The Baseline Cases

We start with data from two country cases, one in a lower-middle-income economy and one in a high-income OECD economy. Both are mining entities, with some basic processing (concentration). The operational expenditures from the two cases are shown in Figures 7 and 8.

⁹The companies involved have agreed to share procurement and other data with the researchers only on the condition that their names and commercially sensitive details be kept confidential.

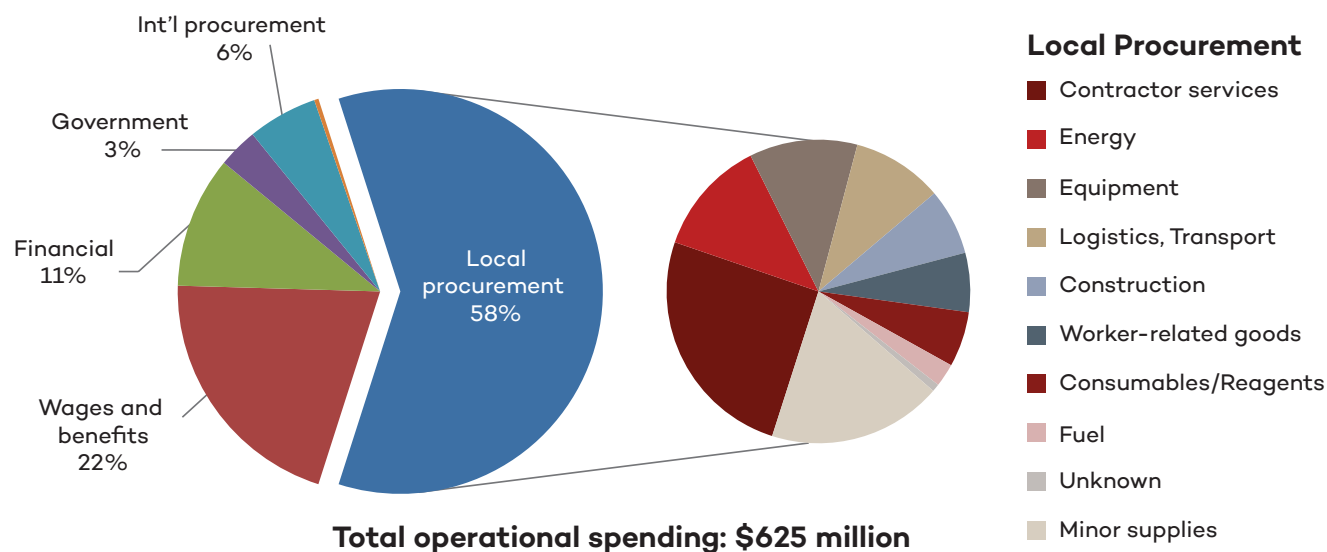


Figure 7. High-income OECD country case

Source: Procurement figures from company-furnished data. All other figures from 2014 corporate reports.

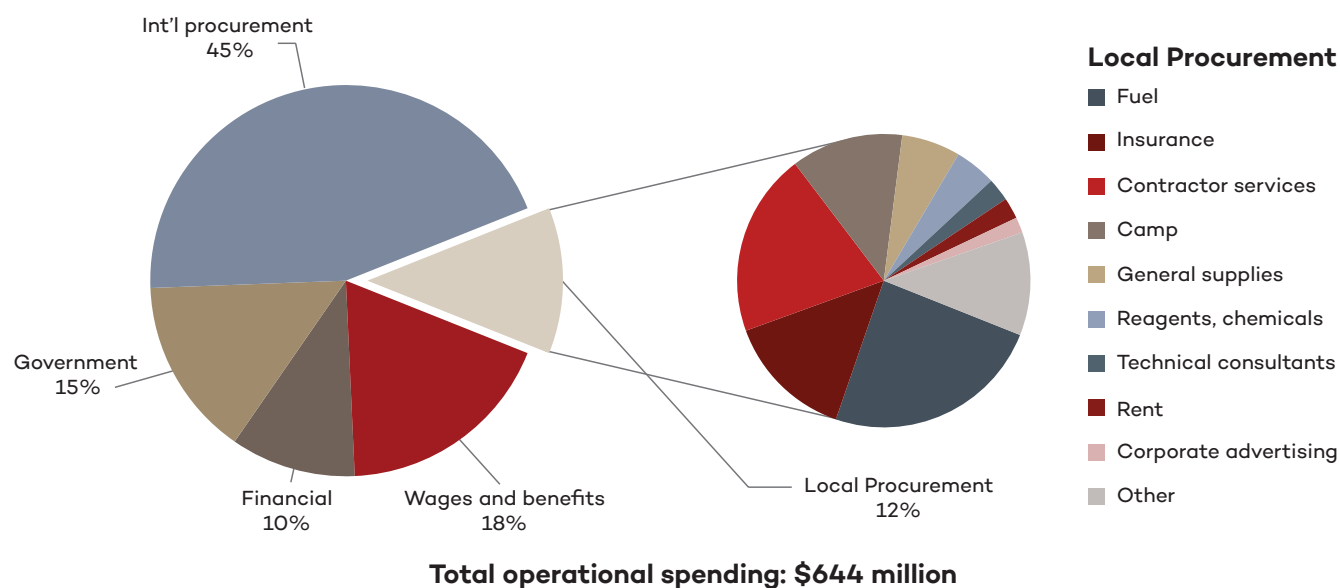


Figure 8. Lower-Middle-Income Country Case

Source: Procurement figures from company-furnished data. All other figures from 2014 corporate reports.

The distinction between local and international procurement is worth exploring. In this paper, we define local as sourced within the country of operations. Local spending by a mining operation plays a significant part in determining its contribution to the community, regional and national economies, in terms of both direct spending and the ripple impacts—indirect and induced impacts—of direct spending (discussed below).

There is a marked difference between the proportion of local and international spending in the two case study operations. For the high-income OECD country mines, local procurement amounted to 58 per cent of total



operational expenditures. Of that, 12 per cent was local to the mine sites, 24 per cent was regional and 64 per cent was spent in the host country outside of the region. The lower-middle-income country operation, by contrast, procured only 12 per cent of its goods and services within the host country.

This finding is not surprising. We would expect to find greater capacity in domestic suppliers of goods and services in more developed countries. But it has important implications for the way in which the advent of automation will affect the contributions of mining to host country economies—a matter explored more fully below.

It is worth noting that even those items recorded as sourced locally will not contribute equally to the host economy. For example, the largest single item procured locally by the lower-middle-income country operation was diesel fuel for its fleet, at 24 per cent of local procurement.¹⁰ As the host country produces almost no petroleum products, the main impacts of that “local” purchasing are probably benefits for local re-sellers—a modest economic contribution. In fact, each category of spending will have different “output multipliers.” A dollar spent by a mine on excavator services has *direct* effects—the actual spending by the mining operator on goods and services. There are also *indirect* effects: the spending that must be done by suppliers of goods and services in order to meet the demand of direct spending. For example, a portion of a dollar spent on excavation demands some smaller portion of that dollar in turn spent by the supplier on machinery, fuel, maintenance, etc. Each dollar spent on a particular category of expenditure has associated with it a final dollar-value impact that is greater than one dollar, once all the direct and indirect impacts are added up; this is an output multiplier.

Spending that involves purchasing imports is not counted, since that money leaves the local economy. Items that involve few imports, such as locally produced food, may have a high output multiplier, while purchase of diesel from importers will have a very low output multiplier (close to 1.0). This is relevant because it suggests that the local procurement of the lower-middle-income country operation, low as it is at 12 per cent of operational spending, may have even less impact than it appears. The less developed the economy, the greater the need to rely on imports of intermediate and capital goods, as well as services. The high-income OECD country operation, by contrast, may be purchasing significant amounts of domestically produced intermediate goods, capital goods and services.

A broader output multiplier includes not only direct and indirect effects, but also *induced* effects of spending. Induced effects occur when the employees drawing pay from direct and indirect spending in turn spend their pay on other goods and services, adding another wave of impacts. If those workers save instead of spending their income, the effect is similar to that of imports—that money does not immediately contribute to the subsequent wave of ongoing economic impacts, and the multiplier effect is diminished.

The output multiplier that sums up direct and indirect effects is called the type I multiplier, and one that includes direct, indirect and induced effects is called the type II. Type I multipliers generally underestimate real impacts, since they ignore employees’ spending as consumers, and type II multipliers tend to overstate real impacts because of rigid assumptions about labour income and consumer spending.¹¹ The two output multipliers are sometimes conceived of as the lower- and upper-bound estimates of output impacts. We will use both below to assess the impacts of automation on host economies.

4.2 The Impacts of Automation

The technology survey (Section 3) described a number of types of process changes that we might anticipate as drivers for change in the mining sector. It noted that, while there is not enough research into the impact of automation on the size of mining workforce, we have two broad estimates on which to base our scenarios. The

¹⁰ According to the records, these purchases are only roughly 20 per cent of total fuel purchased—the remainder is recorded as purchased internationally.

¹¹ Type II multipliers treat household consumption as constant, with the ratio of expenditure-to-income fixed for all levels of income.



Cluster Research Report (McNab et al., 2013, p. 16) suggests that the introduction in mines of fully autonomous equipment “would reduce the workforce of a typical open-cut, iron mine by approximately 30 to 40 per cent.” In another report, Accenture (2010) evaluated the economics of three types of equipment (trucks, dozers and drills), suggesting that automation could reduce the number of operators in open pit mines by up to 75 per cent. These two reports are not explicit about the geological and technical conditions of the mines evaluated, so the best employee reduction rate to be applied to our case study sites remains unclear. In order to have a general view of the impact of workforce reduction on local procurement, we build three scenarios of workforce reduction through automation, conservatively bracketing the two estimates cited above with rates of 30, 50 and 70 per cent.

Doing so involves going through the detailed procurement accounts for each firm and deciding which would be sensitive to changes in workforce size. This would be the case for worker-related goods such as food, clothing, safety equipment, housing and camp materials. Other categories of spending, such as workers’ insurance, human resources and provided equipment such as cell phones, will also be affected.

Beyond the impacts of workforce reduction, we noted above that driverless technology using equipment under control (EUC) will have impacts by saving on fuel consumption. Researchers from the University of British Columbia estimate that driverless technology can bring about a 10–15 per cent decrease in fuel consumption (Spence, 2014). The size of the mining operation as well as the fleet, commodity and mining method are parameters that must be taken into account. However, since there is no literature available, these considerations are not included in this analysis, and we assume a 12.5 per cent decrease in diesel consumption in our scenarios. In addition, assuming that haul trucks in the mine are using EUC and using the rate calculated by Fortescue in its iron mines in Australia, an extra 2.3 per cent in fuel savings could be achieved if they are installed in trucks (Australian Government, Department of Resources, Energy and Tourism, 2014). Therefore, based on the literature review, we assume that mines could save 14.8 per cent in fuel used for hauling if they implement autonomous systems and EUC.

Our data set does not show what portion of purchased fuel is used in hauling activities, a figure that will vary from site to site depending on a host of factors. As well as hauling, diesel is used in generators in off-grid sites, and even as a processing fuel. We assume below that 50 per cent of diesel in our sites is dedicated to hauling, and apply a reduction factor of 14.8 per cent to this value. The 50 per cent figure is a conservative estimate that likely underestimates the impacts of fuel savings.

4.2.1 GDP Impacts

Figures 9 and 10 show the impacts on local procurement of the three scenarios described above: reductions in workforce of 30, 50 and 70 per cent, combined with savings of 14.8 per cent in fuel locally purchased in all cases. The results indicate minor impacts relative to total local procurement. In the high-income OECD case, local procurement drops by 2, 3 and 4 per cent respectively in the three scenarios. In the lower-middle-income country case, the corresponding figures are 6, 9 and 11 per cent.

The main elements of the reductions are employee housing-related expenses, including construction, but safety equipment and employee benefits also feature strongly in the high-income OECD country case. Fuel savings remain constant at a fairly low level irrespective of the workforce reduction scenario. But worker-related expenditures are not the most important elements of local procurement in either case. This is consistent with the data in Figures 7 and 8, where local procurement is broken down into its component parts for both operations.

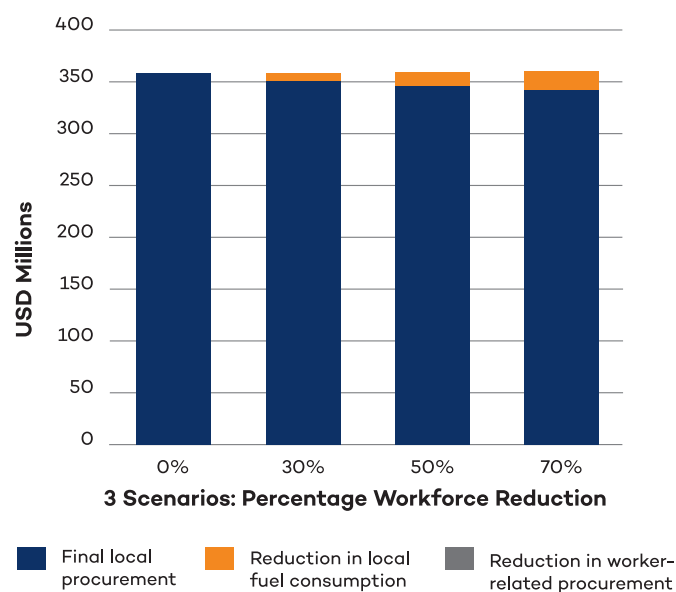


Figure 9. Impacts Of Automation On Local Procurement (High-Income OECD Country Case)

Source: The authors

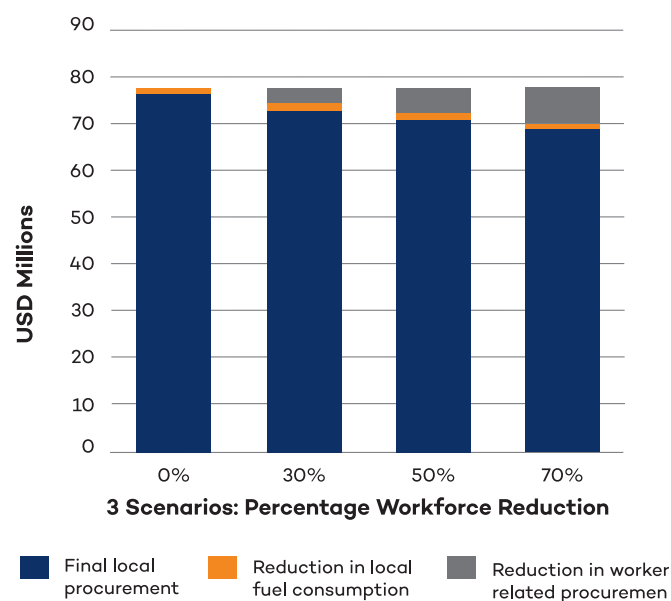


Figure 10. Impacts Of Automation On Local Procurement (Lower-Middle-Income Country Case)

Source: The authors

Where the operations constitute a large part of a community's economy—often the case in mining operations—the sort of reductions seen here may be significant at the local level: depending on the scenario, between USD 7.2 million and USD 15.8 million less spent in the high-income OECD case, and between USD 4.6 million and USD 8.9 million less spent in the lower-middle-income country case. In the high-income OECD case, under a 70 per cent scenario, we would see USD 3.3 million less spent in the local communities, and USD 7.6 million less spent in the region. The indirect and induced impacts would amplify these effects.

As noted above, not all withdrawals from a local economy will have equal impacts. At the community level, reductions in services such as construction will probably weigh much more heavily per dollar than reductions in fuel purchases, assuming that most of the value of the fuel is imported and most of the value of construction is in the labour provided, and thus is local.

While these impacts seem relatively small, they only cover a portion of the total impacts of mining automation. They do not cover the direct loss of wages and salaries for mine employees, and they do not cover the indirect and induced impacts of reduced spending. These elements are introduced in turn below.

Figures 11 and 12 show the impacts of automation when salaries and benefits for mine workers are included in the analysis. (Note that while spending on procurement and wages and benefits drops, we assume that payments to government are unchanged). These figures show clearly that while procurement drops in all scenarios, the impacts of reduced payroll are much more significant. In the high-income OECD country case, reduction of wages and benefits are responsible for 86 per cent of the impacts shown here, and in the lower-middle-income country case they are responsible for 92 per cent.



The final impacts are significant in terms of total GDP (output) contributions from the operations. The reduction in those contributions in the high-income OECD case ranges across the three scenarios from 9 to 20 per cent. The corresponding range for the lower-middle-income case is higher: from 13 to 31 per cent. This may seem strange; the latter operation's salaries are roughly half of the former's, so the impact of lost wages should be blunted relative to the high-income case. The explanation is that local (national) procurement is much lower in the lower-middle-income country operation (see Figures 7 and 8). So even though payroll is lower in that operation in absolute terms, it makes up a larger percentage of a mine's contributions to the national economy. Its loss is therefore more significant as a percentage of those contributions.

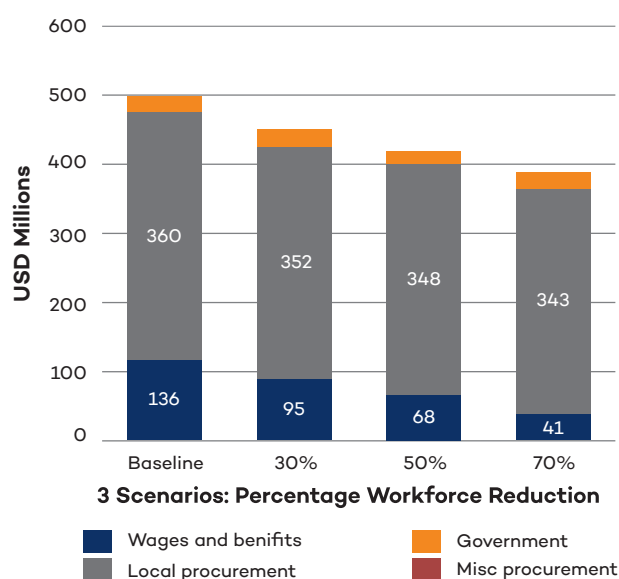


Figure 11. Impacts Of Automation On GDP Contribution (High-Income OECD Country Case)

Source: The authors

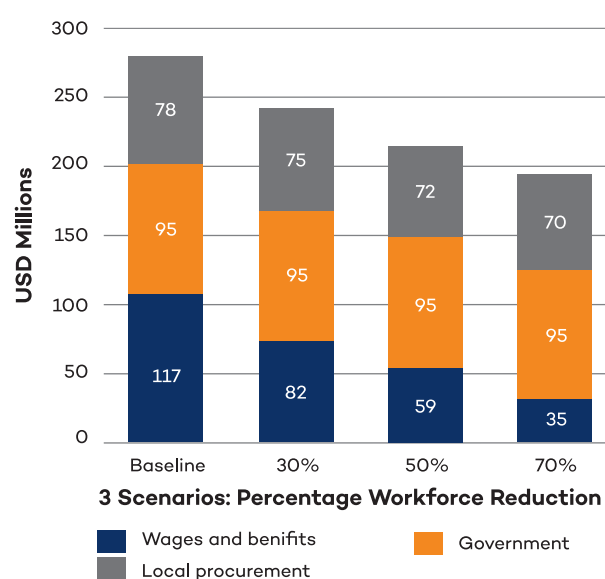


Figure 12. Impacts Of Automation On GDP Contribution (Lower-Middle-Income Country Case)

Source: The authors

The effects discussed up to this point have all been strictly direct impacts of mining expenditures. Indirect effects and induced effects are also appropriate to consider, and are routinely described in the literature assessing the beneficial impact of mining investment.

Table 1 shows the impacts of automation on national GDP, when output multiplier effects are included.¹² Again we considered the three workforce reduction scenarios.

¹² Appendix A discusses the limitations of the use of multipliers in this analysis.

**Table 1. GDP Impacts, With Multipliers**

	Direct Impact	Direct + Indirect	Direct, Indirect + Induced	Total impact as % of total multiplier effects of mine	Total impact as % of national GDP
High-Income OECD Country Scenarios					
30%	55,931,204	75,507,125	92,006,831	8.5%	<0.01%
50%	92,736,431	125,194,182	152,551,429	14.0%	<0.01%
70%	129,541,658	174,881,238	213,096,028	19.6%	>0.01%
Low Middle-Income Country Scenarios					
30%	39,843,100	103,592,059	124,310,471	6.2%	<2%
50%	65,474,572	170,233,887	204,280,664	10.2%	<3%
70%	91,106,044	236,875,715	284,250,858	14.1%	<4%

Note: Multipliers used are from the national accounts of the respective host countries.

Source: The authors

The results show a reduction in contributions to the national economies of the host countries ranging from USD 92 million to USD 284 million, when we consider direct, indirect and induced impacts. These are big numbers, but they are difficult to put into context without knowing the size of the national economy, or the total size of the contributions of those operations—the totals from which these reductions are subtracted. Table 1 helps on both counts. It shows that the reductions in terms of total national GDP are insignificant in the high-income OECD country, at most just exceeding 0.01 per cent. In the lower-middle-income country the percentage is higher, ranging from just below 2 per cent to just below 4 per cent of national GDP. Table 1 also shows the percentage reduction these impacts imply for the total contributions of the operations to their respective national economies. That is, if we consider the total impact of the mines' operations, including indirect and induced impacts, with and without the automation-related changes, what percentage change will we see? In the high-income OECD case, the percentage decrease ranges from be 8.5 to 19.6 per cent, while the lower-middle-income country range is from 6.2 to 14.1 per cent.

These figures should be put into the broader context dictated by the shared-value paradigm. Procurement is not the only way that mining operations contribute to the well-being of their host communities, regions and countries. As discussed in Section 2 above, the shared-value paradigm also conceives of other important classes of spending—on infrastructure like roads that are shared by the general public, for example, or on downstream processing and beneficiation operations. It is not envisioned that automation of the type surveyed above will significantly affect these categories of spending and, where they are present in any significant measure, the estimates derived above will overstate the relative magnitude of automation's impacts.

4.2.2 Employment Impacts

Another way of assessing the impacts of mining expenditure is by measuring the number of jobs created. Employment is expressed in terms of full-time equivalent staff and does not count head office employment or contractors. As with GDP measurement, impacts can be conceived in terms of direct employment, indirect employment by suppliers and induced employment as a result of direct employee spending. The direct impacts are straightforward, and are presented in Table 2.

**Table 2. Employment Impacts**

	Lower-Middle Income	High-Income OECD
Full-time-equivalent staff	2,550	1,457
Of which, domestic staff	2,470	1,457
Payroll (USD)	118,579,207	135,773,223
Average salary	46,502	93,176
Income taxes paid	11,857,921	25,693,953
Jobs created, direct and indirect	5,100	3,388
Jobs created, direct, indirect and induced	n/a	4,801

Source: Corporate annual reports from 2014.

These figures include employees but not contractors. They use sectorally applicable national employment multipliers from both countries' national accounts. Similar to output multipliers, employment multipliers tell us how many jobs are created for a given level of spending. A type II employment multiplier is not available for the lower-middle-income country case, but the total impacts would be significantly higher than those estimated by the type I multiplier alone.

These baseline case figures for jobs created can be modified using the three scenarios for job loss to get a picture of the types of impacts automation might have in terms of employment. Table 3 shows the baseline cases under the three scenarios used above, showing total job loss under each. Only direct and indirect multiplier effects are considered, as a type II employment multiplier is not available for the lower-middle-income country. The analysis here is necessarily crude, and these figures need to be taken as rough indicators only. The employment multiplier assumes a fixed ratio of additional jobs created per direct job created, using data that describes interrelationships with existing technologies. The assumption of existing technologies does not hold here, as the basic change we are positing is a less labour-intensive operation. The final impacts of any given reduction in workforce should therefore be less significant than what we might derive in this analysis. Given that the type I multiplier used here is, as noted above, a sort of lower-bound estimate of total impacts, however, the figures here can serve to give a rough idea of the magnitude of expected impacts.

Table 3. Employment Impacts, With Multipliers

	Lower-Middle Income			High-Income OECD		
	30%	50%	70%	30%	50%	70%
Baseline jobs, direct	1,785	1,275	765	1,020	729	437
Baseline jobs, direct and indirect	3,570	2,550	1,530	2,372	1,694	1,016
Direct and indirect job loss	1,530	2,550	3,570	1,016	1,694	2,372

Source: Corporate annual reports from 2014



4.2.3 Government Revenue Impacts

The final category of impact is government revenue. Here we include taxes, royalties and dividends paid by the firm to all levels of government in the host state. We also include, separately, the estimated value of personal income tax paid by employees as a result of mine employment. We have assumed that the former will not change significantly as a result of automation, though that assumption is surely wrong: we expect automation to increase profitability, and corporate income tax and dividends are linked to profits. It would be difficult, however, to make any meaningful estimates as to their magnitude and nature as they will depend so critically on the specific context of each operation. Personal income tax revenues, however, should change significantly.

The baseline case for government revenues is shown in Table 4. We averaged direct payments to government over three years of remittances (2012–2014) for each operation, and estimated income taxes paid by assuming all employees earn the average salary for both operations, assuming benefits are rolled into salary, and assuming no tax deductions. Average annual salary for employees in the high-income OECD country operations under these assumptions is USD 93,176, while average salary in the lower-middle-income country operations is USD 46,502. We then use the income tax regimes for both countries to derive the payments due at those salary levels.

Government revenues from payments made to government and income taxes of mine employees are twice as high in the lower-middle-income country case, driven by higher payments to government. Employee income tax rates are almost double in the high-income OECD case, and the average salary is twice as high, but that is not enough to mitigate the effect of the large difference in direct government payments; the latter are 4.5 times higher in the lower-middle-income country case. As Table 4 shows, some of the difference is made up when induced impacts are considered; in this case, the high wages and tax rates in the high-income OECD country case strongly influence the induced spending impacts.

Table 4. Government Revenue Impacts

	Lower-Middle Income	High-Income OECD
Direct payments to government	95,157,441	21,002,633
Income tax, direct employment	11,857,921	25,693,953
Total, direct revenues	107,015,361	46,696,586
Direct payments	95,157,441	21,002,633
Income tax (with total multiplier effects)	25,485,720	105,749,750
Total, direct and induced	120,643,160	126,752,382

Notes: Multiplier effects for the high-income OECD case use a type II national labour income multiplier. For the lower-middle-income case, a type II labour income multiplier is unavailable, and an output multiplier is used, adjusted upward by the ratio of the high-income OECD output and labour income multipliers.

Source: Corporate annual reports from 2014.



The impacts of automation on the baseline cases can be seen in Figures 13 and 14.

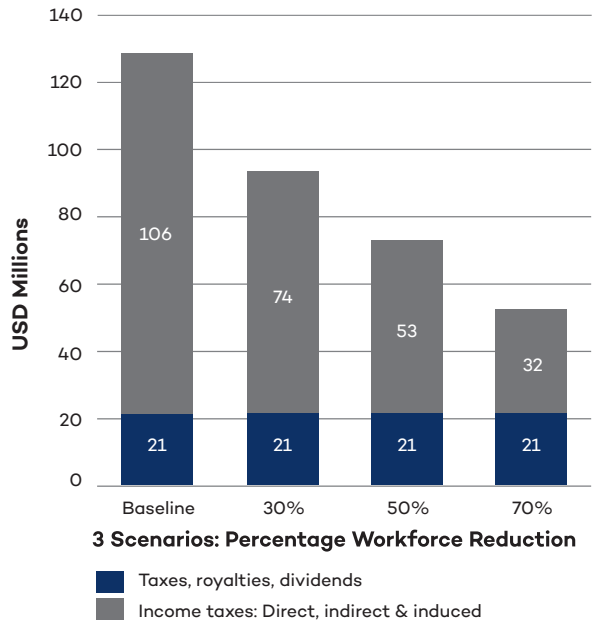


Figure 13. Impacts Of Automation On Government Revenue (High-Income OECD Country Case)

Source: The authors

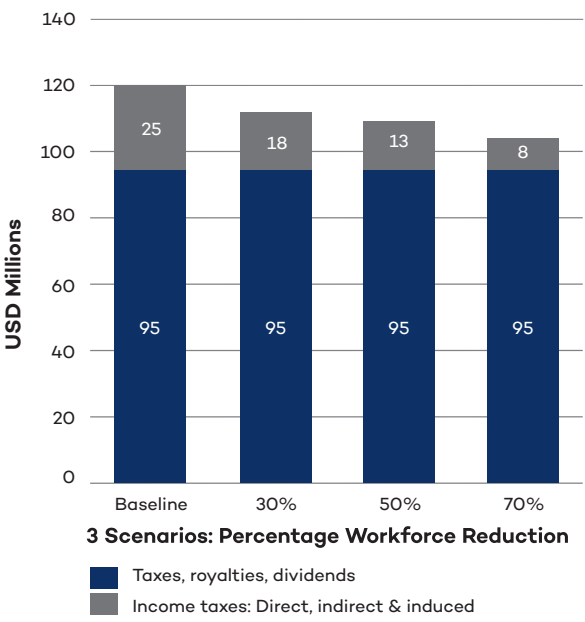


Figure 14. Impacts Of Automation On Government Revenue (Lower-Middle-Income Country Case)

Source: The authors

The final impacts are more significant in the case of the high-income OECD country; higher wages and higher personal income tax rates make the lost tax revenue much more significant there (despite a higher assumed labour income multiplier in the lower-middle-income country case), with a range of revenue drop from 25 to 58 per cent, depending on the scenario. The corresponding figures for the lower-middle-income country case are 6–15 per cent. This disparity underscores the sensitivity of government revenue streams to the structure of the tax regimes in the host country; the lower the direct charges (taxes, royalties and dividends) and the higher the levels of personal income tax revenues, the greater will be the impacts of labour-saving automation.

In absolute terms, the significance of the impacts will depend on the share of government revenue that is occupied by payments from mining operations. In our two cases, the reduction in revenues, including direct, indirect and induced income tax revenues, was USD 7.6 million to USD 17.8 million in the lower-middle-income country case and USD 31.7 million to USD 74.0 million in the high-income OECD country case.



5.0 CONCLUSIONS





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Our analysis suggests that host countries will be increasingly at risk of reduced socioeconomic benefits from mining as existing new technologies are further rolled out in the near and medium terms. The impacts will be primarily in terms of lost local employment and personal income tax revenue, but will also come from reduced employment-related local procurement.

The significance of these impacts will vary from case to case. At the community level they may be much more acute, while at the national level countries that depend more on mining economic activity will feel them more strongly. At first blush, several factors seem to indicate that the effects will be more significant in developed countries:

- The technologies surveyed will be more readily rolled out in high-wage host countries, where the economic proposition for investing to save labour is strongest.
- The largest absolute impacts on GDP and government revenue will come in countries where wages and personal income taxes are highest.
- Baseline domestic procurement tends to be higher in developed economies that are more capable of delivering local goods and services at qualities and quantities acceptable to the investors.

However, there are reasons to believe that developing countries will feel the social and economic development impacts more strongly than developed countries. First, we noted that most strategies for adapting to these types of changes are fiscally and technically demanding, and more likely to be successfully undertaken in developed countries. Second, more developing countries suffer from acute over-dependence on the extractives sector. Third, we noted that some types of technological change will involve no net loss in employment, but simply a shift to higher skills employment; for those host countries that struggle to supply high-skilled labour, this will exacerbate the problem of the sourcing of foreign workers. As well, even though wage levels are lower in developing countries, reducing employment there may serve other objectives, such as addressing skills shortages or circumventing strong unions. Finally, though our analysis was unable to confirm this, it is likely that the mine of the future will involve decreased equipment-related procurement from local vendors, as new, more complex operating systems are imported and serviced from abroad.¹³ This will likely include original purchases as well as long-term maintenance and repair. If so, the source countries for such imports, including ongoing maintenance contracts, are likely to be developed.

Our framework for assessing these impacts is the shared-value proposition: the overall value received by governments and communities, including fiscal and non-fiscal social and economic development benefits derived from the core expertise and operation of mining firms. In essence, the shared-value paradigm broadens the traditional focus only on taxes and royalties to the full contribution a mine operation can create towards the sustainable development of their host economies.

The shared-value paradigm, as noted previously, was a response to the growth in resource nationalism in the 2000s, which in turn was a governmental response to what appeared to be imbalanced and inequitable value for governments for the minerals they are responsible for. The argument was simple; mining companies can, and must, ensure governments receive better value for the minerals that the governments are custodians of. The industry commitment to the shared-value paradigm was, in effect, reflective of the consent of the private sector to redress

¹³ Confirming this possibility is beyond the scope of our analysis. We are confident that the mine of the future will use much more complex machinery and controls, perhaps produced by a smaller pool of innovative equipment manufacturers. As a general proposition, we see less possibility for local manufacturing and servicing as the product in question becomes more complex, and as original equipment manufacturers seek the long-term profits of technology service contracts, tie warranties to ongoing service, and seek to protect patented and higher-level technologies.



this actual or perceived imbalance. In this context, we have noted that much of the social licence to operate may depend on the degree to which the shared-value proposition holds true. As such, the predicted potential drop in benefits derived from local procurement and employment should be a concern for firms and host countries and communities alike.

We now see the pressure on the local procurement aspect of shared value as part of a larger worrying picture. Mining profitability and new capital investments have experienced a downward trend since 2007 (Walker, 2015) in an “unprecedented global supply restructuring” (EY, 2016: 4). In addition, the potential local benefits from even the existing local procurement have been proving more difficult to realize than had been appreciated during the boom-inspired years of revision to mining codes and regulations. BGR (2016) sets out a number of challenges to making procurement linkages work for host countries in the Southern African mining sector, and Cosbey and Mann (2014) enumerate the difficult prerequisites for the successful use of legislated performance requirements to the same end in the mining sector globally.

This set of dynamics highlights the need to redouble efforts to make local procurement and hiring work for the benefit of host countries. But it also points toward the need for firms, governments and communities to focus on other ways in which mining can contribute to the host economy and host communities. That may come in the form of re-weighting other aspects of the shared-value proposition (Section 5.1), or in the form of revised fiscal regimes (Section 5.2), or in the form of government policies that change in more fundamental ways the relationship between the host state and the mining company (Section 5.3). In other words, the notion of shared value is not likely to diminish, but the means to achieve it for governments may have to be refocused.

5.1 Other Avenues for Shared Value: Re-Weighting the Elements

We noted above that local socioeconomic benefits related to employment and procurement are only part of the shared-value proposition, and we predict that there will be pressure to find ways in which the shared-value proposition can make up the shortfalls that result from technological change.

Figure 15 illustrates the various avenues to realizing domestic benefits, by presenting the linkages to the mining sector that could lead to increased shared value. The mining project is located in the circle within the centre of the blue arrow that represents the mining value chain. This study suggests that automation will reduce the direct employment opportunities, which in turn will reduce the amount of money that employees working at the mine can spend in the local economy (consumption linkages) and the amount of personal income tax revenues to be collected from employees (fiscal linkages). It also suggests that automation is likely to reduce the opportunities for local procurement, particularly in developing countries (upstream linkages). This, in turn, will also adversely affect indirect job opportunities of suppliers. The orange rectangles indicate the reduced opportunities for shared value through the consumption and upstream linkage channel. The fiscal linkage channel is striped orange and blue, given that automation will on the one hand reduce the opportunities for collecting personal income tax payments, but on the other hand provide an opportunity to capture additional value by reconfiguring the fiscal regime (as highlighted in the next subsection).

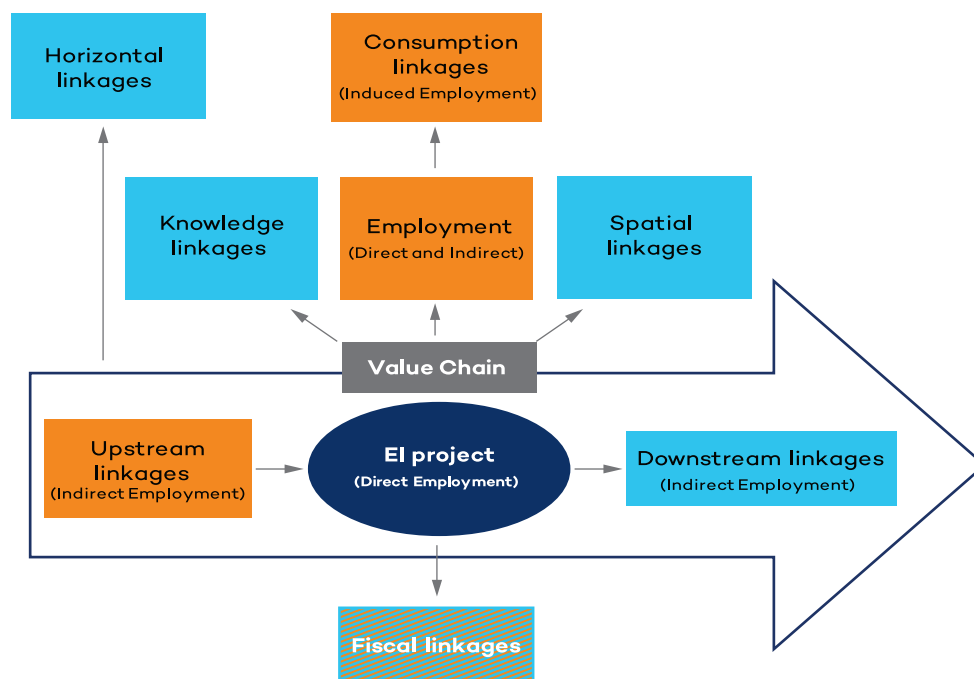


Figure 15: Potential Avenues Of Sharing Value Of Mining Projects

Source: CCSI & GIZ (2016)

Assuming that these three linkages will be adversely affected by automation, there are four other avenues through which shared value can be created—avenues on which we have not focused in this analysis. These are the blue rectangles in the figure above:

1. Downstream (forward) linkages relate to the beneficiation of extracted commodities through refining, smelting and further downstream processing of the commodity before reaching the final consumer. For example, 98 per cent of the world's mined iron ore is used to make steel and therefore needs to pass through a steel mill. Downstream benefits are, for example, a key strategy in the African Mining Vision and broader African economic visions of shifting to a more industrialized economy.
2. Horizontal (lateral) linkages relate to the development of new non-mining-related industries adapting the capabilities developed to serve the mining-related value chain. For example, mining trucks could be re-engineered and adapted to service the logging industry. But it is unclear if this will be limited to a repurposing of older technologies or an ability to utilize new technologies in other sectors.
3. Knowledge (technological) linkages relate to the transfer of knowledge and technological know-how to state-owned companies, the employees of the mine and to the labour force involved in the mine's value chain. For example, the state-owned company acquiring managing and technological expertise through a joint venture agreement with international investors. However, this may be more difficult when high-technology providers seek to protect those technologies.
4. Spatial (infrastructure) linkages relate to the benefits associated with the infrastructure developed for an extractive-industry project profiting other actors in the economy. For example, an iron-ore mine is likely going to require railway infrastructure. Other companies (from the mining sector and non-mining sectors) and passengers may benefit from this railway infrastructure if granted access.



The potential for each of these linkages is very context specific. Railway-sharing opportunities, for example, only exist for bulk commodity mining projects where such infrastructure construction is required, and to the extent that the transport route is valuable to non-mining interests. Downstream processing opportunities will largely depend on infrastructure and water availability (for example, smelting activities are very energy- and often water-intensive) and existing international production capacity (for example, currently there is excess capacity for steel production). Beneficiation (processing raw materials to consumer grade, such as diamond cutting) is notoriously difficult to foster via government policy, and difficult for firms whose core business is extraction and processing, but successful examples exist. However, the adverse impact of automation on employment and local procurement in developing countries enhance the importance of assessing these alternative types of linkages when seeking to maximize the impact of mining for broader development needs.¹⁴

5.2 Revising the Fiscal Element of Shared Value

Perhaps the least intrusive option for governments will be passive receipt of efficiency-driven revenues. The increased productivity and reduced costs resulting from automation should generate increased profits that are then taxable, as well as the possibility of increased dividends to government-held equity. There may also be increased volumes of production that are subject to royalties. This is the minimum response scenario in our view.

Beyond the straightforward formula that sees increased compensatory government revenues coming from increased efficiency and profits, it is likely that governments will seek added benefits to replace lost employment and to impose increased taxes or royalties. This may come in the form of higher tax levels on all profits, or higher royalties on production. This again would rely on traditional tools and approaches within national fiscal regimes.

There may also be options for governments that pursue newer approaches to managing the fiscal regimes in relation to mining. One such approach is to move to more progressive tax regimes in a much clearer way. Given the pressure for better and more transparent reporting practices (see Section 6 below), and as governments become more familiar with the modelling extractive industry projects,¹⁵ it may be possible for them to implement and administer fiscal mechanisms that self-adjust to the profitability of the project, to changes in circumstances and to reduced risk over the life of a project by being progressive with respect to time, costs and prices. This type of fiscal mechanism, also called the resource rent tax or return-based sliding scale profit sharing arrangement, is indexed on the project returns and captures an increasing share of the project profits as these profits accumulate beyond a certain threshold, with the objective of taxing the rent.¹⁶

By ensuring predictable flexibility, this fiscal mechanism ensures stability of the investment but it also means that companies assume lower risks in case of lower profits (resulting either from price decreases or cost increases).¹⁷ While such a mechanism is already widely implemented in oil fiscal regimes, given the higher rents, it has not managed to take a foothold in the mining sector. It was implemented in Australia in 2012, but repealed in 2014 in the face of declining commodity prices (Critchlow, 2014). It was similarly proposed in several other mining

¹⁴ Assessing the impacts of automation on these other types of linkages is beyond the scope of this study. However, it is likely that automation will also have an impact on these. For example, knowledge and technology linkages are most likely to be successful if the “knowledge gap” between the international investor and the host country capacity is not too large. This gap will likely be exacerbated by automation, which might limit the knowledge transfer. This could be countered by public-private investments in technological training and education. Similarly, horizontal linkages may be affected, as the biggest potential for horizontal linkages originate from upstream activities, which are likely to be reduced due to automation.

¹⁵ See the discussion at http://goxi.org/profiles/blogs/public-interest-modeling-don-t-let-the-perfect-the-enemy-of-the?xg_source=msg_mes_network.

¹⁶ Rent is defined as the excess profit above what is necessary to cover the costs and the minimum return necessary to attract investment.

¹⁷ An additional risk for the government generated by return-based fiscal systems is the risk of gold plating, or expenditure deliberately designed to make profits disappear. “The effects of gold plating are more severe if the benchmark rates [the various thresholds in the sliding scale at which the various tax levels kick in] are higher than the hurdle rate [the cost of capital under which an investor won’t invest] and the profit differential is very large” (van Meurs, 2016). The recent Mexican shallow water production-sharing contract illustrates this issue: the benchmark rates of 25 per cent and 40 per cent are far over industry hurdle rates and the reduction of the profit share by 75 per cent is excessive by international standards. This system might lead contractors to embark on wasteful expenditure to improve their profitability by staying in low brackets. To anticipate and avoid gold plating effect through a well-designed sliding scale, fiscal modelling skills will be critical. (Ibid.)



jurisdictions prior the commodity price slump. Automation and its assumed associated increase in profitability combined with reduced benefits from the employment and procurement channels might generate renewed interest for this mechanism from the mining sector.

5.3 Challenges to the Current Shared-Value Approach

A more aggressive approach by governments would begin by asking a different question for the sector, one that essentially reverses the traditional basic question: instead of asking what share of its revenues the company should share with the government, the question could be reversed to ask what level of returns the company should receive. This reversal of the basic question opens governments to very different approaches that might challenge the current approach to shared value in more fundamental ways. For example, this might mean governments maintaining full ownership of the resources and the mining project, as compared to the predominant concession agreement model. This type of direction may be more likely today than it otherwise would be due in part to the difficulties administering tax regimes that are increasingly complicated by tax havens, transfer pricing and other tax base erosion practices, which can impact any fiscal approach to shared value.

An option short of full ownership would be increased ownership by governments—directly or through state-owned enterprises—of mining companies operating in their territories. Under the current model, the prevalent forms of state equity are (i) free equity giving rise to dividends without the governments contributing to the cost of the project; (ii) carried interest, whereby the investor lends money to the government in order for it to contribute to the costs; or, more rarely, (iii) paid-up equity, whereby the government contributes to the cost on equal footing with the investor. The merit of increased ownership for governments is subject to some debate. In particular, the value of such shares is usually based on the value of the dividends received, rather than any value of the equity holdings themselves, because, in most cases, shares cannot be sold to the public. In addition, unless the government has control of the board of directors, or of the parent company board in many instances, dividends remain an uncertain benefit dependent on the decisions of the board. The impacts this would have on increasing the other elements of the shared-value paradigm—local purchasing or downstream beneficiation, for example—are also unclear.

Moving towards alternatives based on maintaining full ownership of the resource and production processes has a history marked by significant failures in different parts of the world. However, experience from other natural resource and infrastructure sectors might be analyzed, and best practices for establishing politically independent and economically efficient enterprises can be applied, if the political will is present to avoid the types of nationalizations that occurred in the immediate post-colonial period. The experience in other sectors, the oil and gas sector for example, has seen a much more divergent set of government–company relationships, such as fee for service contracts and production-sharing contracts that have solidified the operations of state-owned enterprises as well.¹⁸ These forms of government–company relationships start from the premise of the ongoing government ownership of the production process and its fruits, rather than the form of concession model that gives these rights to the company. Similarly, the wave of privatizations in many infrastructure service sectors, such as water supply and sanitation or energy provision in the 1990s and early 2000s, has also given way to alternative forms of service contracts. Indeed, the mining sector more than any other has stayed tied to this pre-colonial concession model of ownership, while other sectors have developed a greater range of options based on government (or state-owned enterprise) ownership.

¹⁸ Technically PSC is about *sharing* of ownership and control between the investor and the host government as opposed to full government ownership. All the options discussed in this section can be applied with slight variations to concession contract models or to full ownership models. A PSC can be a form of payment to a company in lieu of cash, but with full ownership of the resource and operation staying with the state-owned enterprise, as much as it can be a sharing of ownership, joint-venture style



Government ownership would likely expand options for enhancing value in other parts of the shared-value paradigm, especially if linked with other government policies on training and local economic development. Again, however, this would be subject to environmental and economic constraints, as well as realistic appraisals of how to optimize value without putting at risk the value of the mining operation itself.

A failure of the shared-value paradigm to deliver true shared value to host countries may see a deeper investigation into these sorts of ownership and contract options by governments. The shared-value paradigm came about in part as a response to the rise of resource nationalism in the mid-2000s. The types of pressure we see on the paradigm will likely lead to further increases in resource nationalism to try and capture the full value for governments. While this may be more likely to be achieved for new investments, it is unlikely that existing investments would be fully immune.



An aerial photograph showing a large, deep quarry with terraced rock faces. To the right of the quarry is an industrial facility with several large buildings, including a prominent blue one, and a parking lot. The surrounding landscape is a mix of green fields, some trees, and a road. A semi-transparent blue triangle is overlaid on the top left of the image, containing the text '6.0 BEYOND THIS STUDY' in white.

6.0 BEYOND THIS STUDY



6.0 BEYOND THIS STUDY

6.1 Data Limitations

One clear lesson not explicit in the analysis above stems from the lack of readily available data on procurement. Despite offers from approximately a dozen companies, we ultimately found it exceedingly difficult to access data from companies on the kinds and volumes of goods and services they purchase at mine sites. In the end, all but two firms were unable to provide the information initially promised. The companies involved cited a number of difficulties that included:

- Corporate offices having little procurement data at-the-ready from their mine sites; virtually all information had to be requested “to-order” and none of this data was part of any regular internal reporting.
- Different systems of data management and reporting on procurement across the mining sites operated by the same mining corporation.
- Mining sites simply not having systems in place to be able to easily compile data on their procurement.
- Corporate office concerns over “initiative overload” and fearing they would be seeking too much information from sites if data was requested.
- Company fears, particularly from legal departments, regarding the confidentiality and commercial sensitivity of procurement information provided; even very generic data “scrubbed” of any information revealing the nature of a mining company or suppliers was considered problematic to provide in several cases.

Regrettably these data collection challenges are not unique across the global mining industry. Similar projects and research the authors have engaged with encountered similar problems.

Those problems go well beyond creating challenges for the present study. There are a number of negative implications for corporate management, partnership building and government policy-making that come out of a lack of understanding of what mining companies purchase locally. For host states, it becomes difficult to fully exploit the potential economic impact. For companies, missing this information can mean missed opportunities to target particular goods and services to purchase locally, when such purchases could lead to both costs savings and an enhanced social licence to operate.

A good starting point might be an effort by the industry to standardize the reporting in this area, if not for the sake of internal intelligence then in pursuit of ways to salvage the shared-value proposition.

6.2 The Need for More Research

The present study aims to shed some light on the question: What will trends in technology mean for host countries’ ability to benefit from mining investment? We are confident that, even though they draw on a limited data set, our analysis and conclusions are robust, and constitute a valuable contribution to a vital new area of discussion.

That said, there is clearly a need for further research in this area, both in confirming our basic findings and in exploring the nuances of the relationship we have identified. Does it matter, for example, if we are looking at open-pit or underground operations? Would different minerals yield significantly different results? It would also be interesting to explore more fully the relationship between the host country income level and the impacts of technology, both confirming the distinctions we observed and considering middle-income or emerging country cases; our two cases are situated toward the ends of the country income spectrum.



We do not expect the basic message to radically change as a result of further work on the questions we examine. But we fully expect that more research will sharpen our sense of what to expect as the advent of new technologies changes the way mining investment interacts with host countries, regions and communities. The better we understand the changing realities, the better both firms and host countries can ensure the continued relevance of the promise of shared value.



An aerial photograph showing a long line of open-top rail cars filled with dark coal, stretching into the distance. The train is situated in a dry, grassy field. A semi-transparent blue geometric overlay is positioned on the left side of the image, containing the word 'REFERENCES' in white capital letters.

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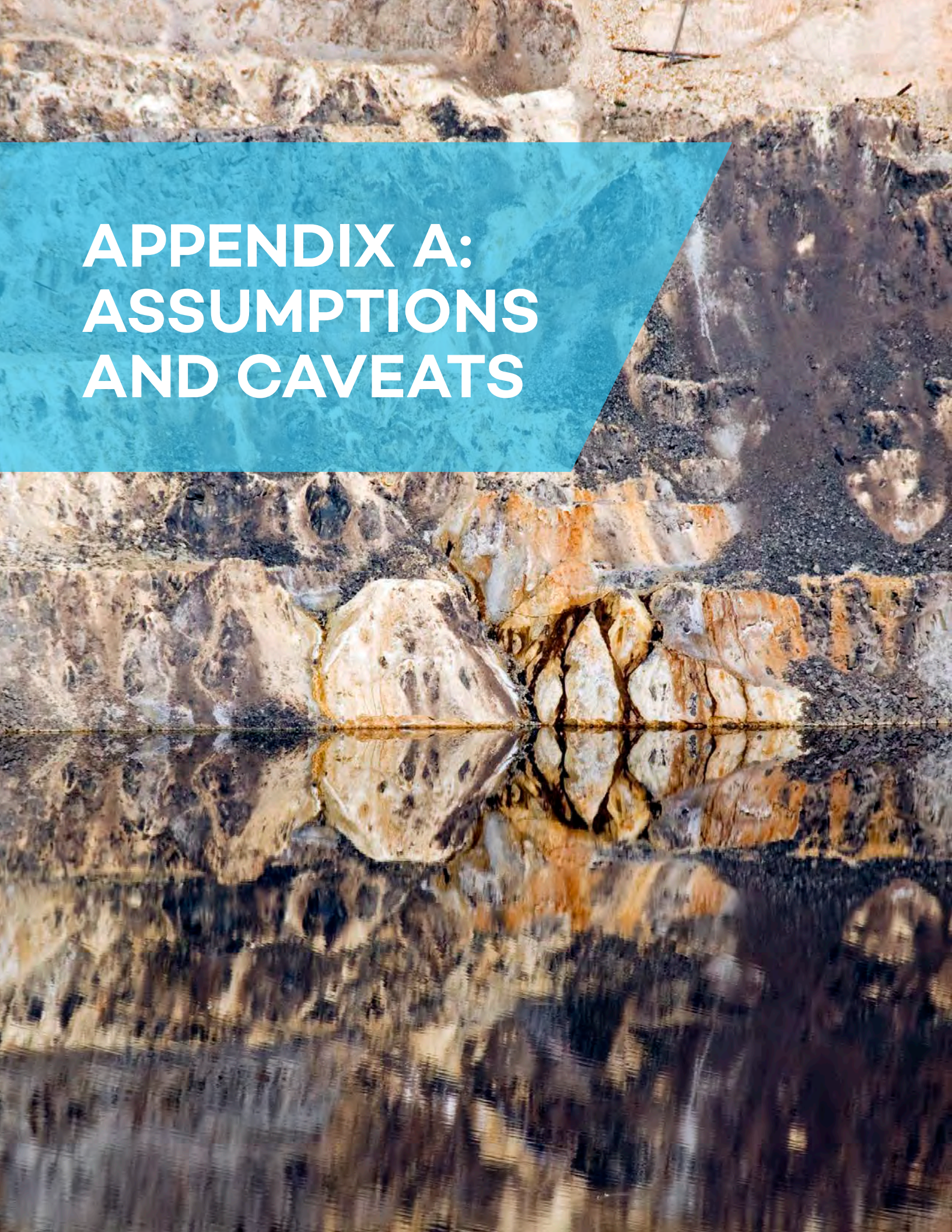
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The background of the slide is a photograph of a geological rock formation. It shows various layers and textures of rock, with some areas appearing more crystalline and others more sedimentary. A prominent feature is a large, light-colored, somewhat circular rock mass in the center. The overall color palette is earthy, with browns, greys, and tans. A large, semi-transparent blue triangle is overlaid on the left side of the image, pointing towards the right. The text is white and bold, positioned within this blue area.

APPENDIX A: ASSUMPTIONS AND CAVEATS



APPENDIX A: ASSUMPTIONS AND CAVEATS

We drew the data used in this analysis from two mining firms, one operating in a lower-middle-income country and one in a high-income OECD country (World Bank classifications). The firms themselves supplied all data on procurement, based on 2014 figures, to the research team. We drew all other data from the firms' respective public corporate reports from 2014 unless otherwise specified. All figures in this report are quoted in U.S. dollars. Exchange rates used are averages from the year of expenditure.

For both operations, data on wages and benefits, and spending on finance and transfers to government are average figures from the operating years 2012, 2013 and 2014. Averages are used to help smooth over some of the variability inherent in these figures.

The high-income OECD country operation reported payments to providers of capital that would presumably be split among several operations, not just those in our case. Given that the operations in our case are by far the major elements of the firm, we have assumed dividends and interest paid are all attributable to the case study operations.

We grouped suppliers for the high-income OECD country into community-level, regional and national by means of their addresses in procurement records. This is not a foolproof method—firms might have local postal addresses or branch offices quite apart from their real central offices.

The number of full-time equivalent employees for the high-income OECD country included all full-time staff and all contract (term) employees. It considered all co-op, summer and part-time staff as half time. We included head office staff (non-local, but national) as employees, but only counted a third of those staff, to account for time spent on purely corporate strategy and on other sites owned by the company.¹⁹ We adjusted reported payments of wages and benefits to account for payment only to those we have assumed are site-specific staff. We did not include contractors as employees for either operation. Excluding contractors from the analysis may understate the impacts of automation, since the expected workforce reductions are only applied to employees when in fact they may also affect contractors.

We calculated personal income tax payable for both countries assuming that all employees are earning the average wage/benefits package. We then applied the respective countries' tax regimes to those earning levels. We assumed no tax deductions, and applied taxes to benefits as well as wages, which means we are probably overstating the estimates of lost government revenues.

The multipliers used are national. In the case of the high-income OECD country, the multipliers are from the national statistical agency's input-output model. They are average figures, a blend of the multipliers for gold and silver ore mining and copper, silver, lead and zinc ore mining. The lower-middle-income country multipliers are World Bank country study estimates for gold mining.

The multiplier analysis is imperfect in two ways. Multipliers are designed to tell us what happens to each incremental dollar of investment in a mining operation. In looking at GDP impacts, we are applying them to incremental dollars spent on salaries and local procurement, but these are only part of the total investment. The multiplier for this type of spending would almost certainly be different. For salaries, the true type II multiplier would undoubtedly be larger. The type I multiplier would probably be lower.

As well, the employment multiplier is based on empirical observations of how many workers are needed to produce a given amount of output. The scenario we are examining fundamentally changes that ratio. So the employment multiplier is not an ideal way to estimate how many jobs would be lost via indirect and induced impacts. In our three scenarios the multiplier should be smaller, as should the final job-related impacts of automation.

¹⁹ The one third ratio is based on estimates provided by the mining company.



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Intelligent Machines

Mining 24 Hours a Day with Robots

Mining companies are rolling out autonomous trucks, drills, and trains, which will boost efficiency but also reduce the need for human employees.

by Tom Simonite December 28, 2016

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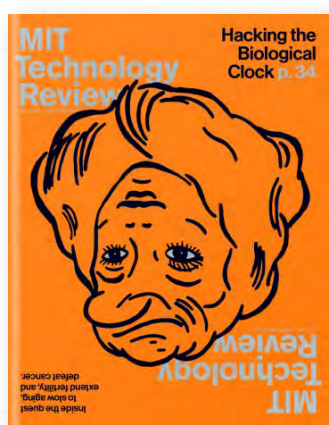
ach of these trucks is the size of a small two-story house. None has
a driver or anyone else on board.

Mining company Rio Tinto has 73 of these titans hauling iron ore 24 hours a day at four mines in Australia's Mars-red northwest corner. At this one,



known as West Angelas, the vehicles work alongside robotic rock drilling rigs. The company is also upgrading the locomotives that haul ore hundreds of miles to port—the upgrades will allow the trains to drive themselves, and be loaded and unloaded automatically.

Rio Tinto intends its automated operations in Australia to preview a more efficient future for all of its mines—one that will also reduce the need for human miners. The rising capabilities and falling costs of robotics technology are allowing mining and oil companies to reimagine the dirty, dangerous business of getting resources out of the ground.



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BHP Billiton, the world’s largest mining company, is also deploying driverless trucks and drills on iron ore mines in Australia. Suncor, Canada’s largest oil company, has begun testing driverless trucks on oil sands fields in Alberta.

“In the last couple of years we can just do so much more in terms of the sophistication of automation,” says **Herman Herman**, director of the National Robotics Engineering Center at Carnegie Mellon University, in Pittsburgh. The center helped Caterpillar develop its **autonomous haul truck**. Mining company Fortescue Metals Group is putting them to work in its own iron ore mines. Herman says the technology can be deployed sooner for mining than other applications, such as transportation on public roads. “It’s easier to deploy because these environments are already highly

regulated,” he says.

Rio Tinto uses driverless trucks provided by Japan’s Komatsu. They find their way around using precision GPS and look out for obstacles using radar and laser sensors.

Rob Atkinson, who leads productivity efforts at Rio Tinto, says the fleet and other automation projects are already paying off. The company’s driverless trucks have proven to be roughly 15 percent cheaper to run than vehicles with humans behind the wheel, says Atkinson—a significant saving since haulage is by far a mine’s largest operational cost. “We’re going to continue as aggressively as possible down this path,” he says.

Trucks that drive themselves can spend more time working because software doesn’t need to stop for shift changes or bathroom breaks. They are also more predictable in how they do things like pull up for loading. “All those places where you could lose a few seconds or minutes by not being consistent add up,” says Atkinson. They also improve safety, he says.

The driverless locomotives, due to be tested extensively next year and fully deployed by 2018, are expected to bring similar benefits. Atkinson also anticipates savings on train maintenance, because software can be more predictable and gentle than any human in how it uses brakes and other controls. Diggers and bulldozers could be next to be automated.

Herman at CMU expects all large mining companies to widen their use of automation in the coming years as robotics continues to improve. The recent, sizeable investments by auto and tech companies in driverless cars will help accelerate improvements in the price and performance of the sensors, software, and other technologies needed.

Herman says many mining companies are well placed to expand automation rapidly, because they have already invested in centralized control systems

that use software to coördinate and monitor their equipment. Rio Tinto, for example, gave the job of overseeing its autonomous trucks to staff at the company’s control center in Perth, 750 miles to the south. The center already plans train movements and in the future will shift from sending orders to people to directing driverless locomotives.

Atkinson of Rio Tinto acknowledges that just like earlier technologies that boosted efficiency, those changes will tend to reduce staffing levels, even if some new jobs are created servicing and managing autonomous machines. “It’s something that we’ve got to carefully manage, but it’s a reality of modern day life,” he says. “We will remain a very significant employer.”

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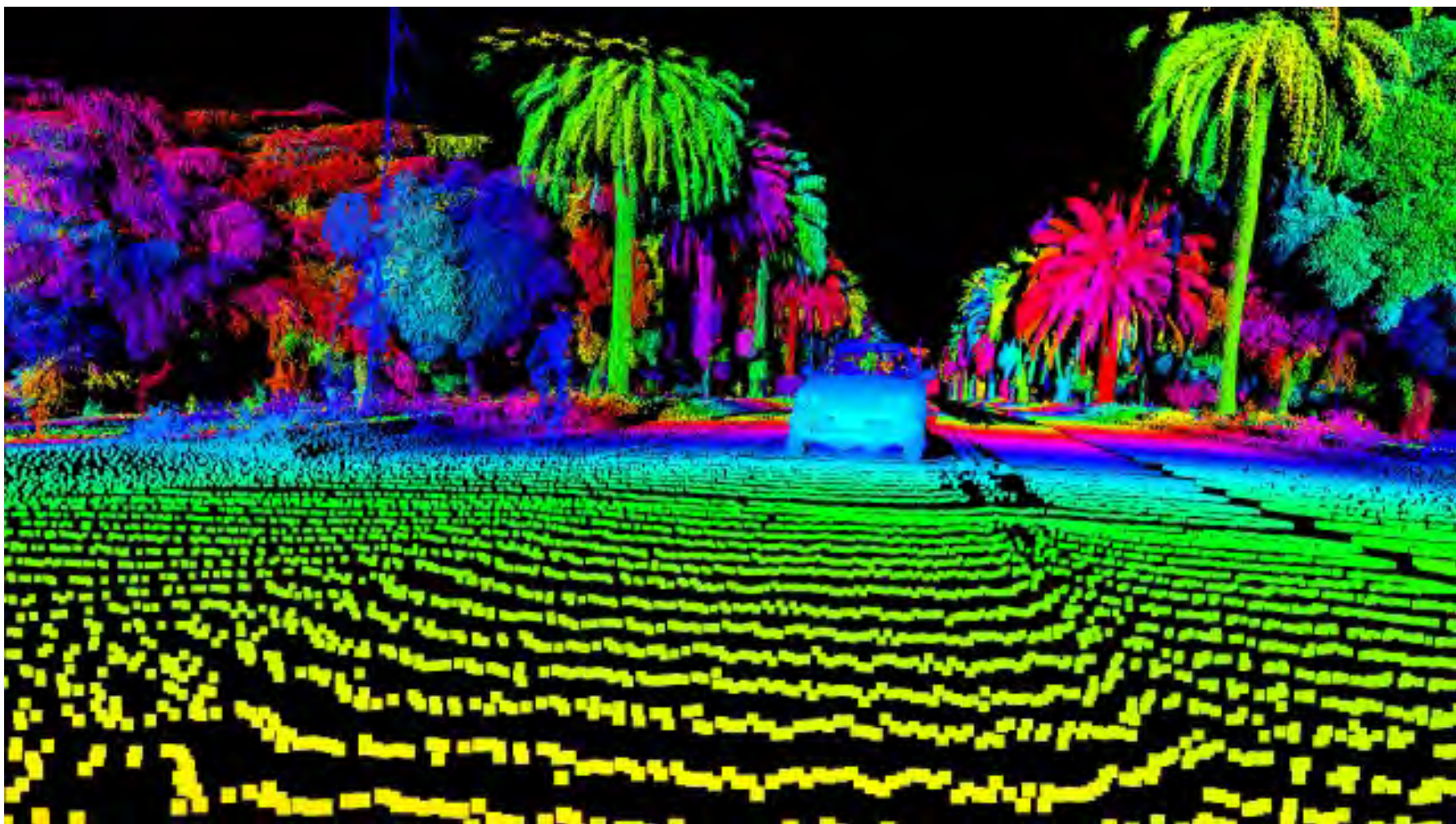




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Robots Will Run Mines Within the Next Decade, Anglo Says

By **Thomas Wilson**
November 29, 2017, 7:58 AM CST

- Mining systems will be ‘unrecognizable’ in 5 to 7 years
- Anglo plans to use virtual models, high-tech cooling in mines

Some mines in the next decade will run without humans and instead rely on robots, virtual models and sensors, according to Anglo American Plc.

Anglo is betting on technology, such as computerized drills with "chiseling ability as good as a human" to increase productivity, cut costs and reduce environmental impact, Tony O’Neill, technical director at Anglo, said at the Mines and Money conference in London.

"The industry that everybody currently knows will be unrecognizable" in five to seven years, O’Neill said. With mining processes automated, Anglo’s "employee of the future" will only need to focus on managing the company’s relations with governments and communities that live near its mines, he said.

Anglo operates some of the world’s most valuable copper deposits and employs 87,000 workers from South Africa to Chile.

Bots, or software that can execute instructions, will be increasingly important in underground mining, O’Neill said. Small and self-learning, the technology requires less infrastructure than current methods, and commercial application is five to seven years away.

Anglo isn’t the first to invest in automation. In Australia’s Pilbara iron ore region, BHP Billiton Ltd. has begun work aimed at implementing autonomous trains along its 1,300-kilometer rail network. Barrick Gold Corp. is a year into the gold mining industry’s most ambitious experiment to modernize digging, using thousands of sensors at and around the Cortez mine in Nevada.

Other technology uses real-time, virtual models of physical processes to prevent problems before they occur and can be deployed to monitor the mine, processing and distribution, O’Neill said. The systems, borrowed from the

aerospace industry, could increase productivity by about 20 percent and lower costs by 15 percent, he said.

The company plans to use so-called "dry water" for cooling and other processes that use lots of liquid. It also aims to reduce mine waste, which would make tailings dams unnecessary.



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The Robots Are Coming

Taking the miner out of mining is a common theme these days as the pace of advance of artificial intelligence and big data goes from a buzz phrase to business-as-usual, and as the move through semi to full automation goes from a dream to a reality.

Caption for image: MacLean BH3 Blockholer working 9,000 underground in the Canadian Shield.

MacLean Engineering (/author/slistermacleanengineering-com) | 01 Oct 2017 | 2:58
| (http://www.miningmagazine.com/sponsor-showcase/maclean-engineering-sponsor-showcase/the-robots-are-coming/#disqus_thread)



As a manufacturer that established its name in large part around the successful integration of one part of the mining cycle into another (the 'MacLean' bolter, going back to the 1980s), we have a unique perspective on the mine of the future where that one aspect of underground mining – ground support – will not necessarily be done in the same way as it is now.



We spend a lot of time thinking about what ground support requirements might look like in underground mines that will be designed, developed and come into production in the next decades, and how the mining cycle will evolve, adapt and fundamentally change with the advent of new technologies like continuous mining and fully automated operations.

Taking the miner out of mining is a common theme these days as the pace of advance of artificial intelligence quickens, as big data goes from a buzz phrase to business-as-usual, and as the move through semi to full automation continues. Autonomous operations are a key part of many mining companies' innovation roadmaps – at some point down the road, that is where the bulk of the innovation will be. But we have lots of ground to cover and many years of advances to get through, before we get there in full.

So what do we all do, mining companies and suppliers alike, in the interim? As a Deloitte UK study from 2017 found, the rise of robots and AI isn't a zero sum game towards machines and away from humans:

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Automation has already transformed manufacturing and so it will mining in due course, but that doesn't mean that the mines of future years won't require people to run them. The nature and location of those jobs may change, but the need to get out of the ground in a safe and efficient manner.

As mining goes from semi-mechanized to semi-automated to fully automated over the next decades, each company will forge a different path with different timelines, but inevitably the endpoint will look more alike than the starting point. For a company like MacLean, the question is really, how do we pursue both incremental change and step change? How do we align our business with the long-term, multi-generational trends in the mining industry, while also keeping our focus on the coming years/decade where most mines will still be planned, built, and operated largely using current practices and technology.

Case in point – as underground mines get deeper around the world and seismic pressures intensify, providing a high quality ground support installation at the face was a new feature we absolutely needed to add to our bolter, which we did with the 975 Omnia Scaler-Bolter launched last year. The latest generation MacLean bolter not only bolts the face, it is higher reaching, has a greater payload capacity, further removes the operator from the end, and provides even greater versatility in terms of the range of bolt types that that unit is engineered to handle (including resin pushing, with bolt handling). All of this done by a single operator always working underground and loaded up with enough screen and bolt supplies to last an entire shift.

These features are evolutionary not revolutionary, but together they deliver a ground support tool that provides the necessary mix of operator safety, productivity, and versatility and quality of ground support installation. As we understand that as mines move further into real-time monitoring and predictive maintenance to drive

ramp up productivity, we needed to be equipping our units with the latest in vehicle telemetry and underpinning that with real-time connectivity that is increasingly the norm not the exception in mining operations.

So stay tuned as mining companies around the globe push the innovation envelope: from Barrick's Comstar in Nevada, to Dundee's Chelopech mine real-time tracking in Bulgaria, to Goldcorp's all-EV Borden project, to continuous miner testing in multiple locations with the potential end result of not just the compression of the mining cycle (drill, blast, ventilate, muck, scale, bolt, repeat...). All to say, an industry being 20 years behind surface construction with regard to the integration of new technology, is in the process of disproving that age-old wisdom.

However fast technological change actually happens, whatever black swans loom over the horizon and commodity prices, we all know that the way that mining is done today is not the way that mining will be done in 10 or not 50 years. There's arguably nothing more important to focus on, given the current pace of technological change and macro-economic uncertainties of commodity pricing, than staying as nimble and forward-thinking as possible while keeping the lights on and the ore flowing.



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Centerra rises as it looks to the future (<http://www.mining-journal.com/profit-and-loss/news/1315844/centerra-rises-as-it-looks-to-the-future>)

Miners continue to face corruption challenge (<http://www.mining-journal.com/mine-risk-management/news/1315843/miners-continue-to-face-corruption-challenge>)

Ity looks to get a bit bigger (<http://www.mining-journal.com/resource-definition/news/1315842/ity-looks-to-get-bit-bigger>)

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Partial List of Minnesota Businesses With Focus On 3-County Arrowhead Region

REGION	BUSINESS	DESCRIPTION	ADDRESS	CITY	STATE	ZIP
Babbitt	Alderplace- The Inn	Lodging	13 Alder Rd	Babbitt	MN	55706
Babbitt	Birch Lake RV Park-Campground	Lodging	2015 Hwy 623	Babbitt	MN	55706
Babbitt	Blomberg's Cenex	Oil & Propane	26 North Dr	Babbitt	MN	55706
Babbitt	Duane's Outfitters	Outfitting	3145 Hwy 21	Babbitt	MN	55706
Babbitt	Junction Inn & Suites & Conference Center	Lodging	2681 Cty Rd 70	Babbitt	MN	55706
Babbitt	Junction Bar & Grill	Food	2667 Cty Rd 70	Babbitt	MN	55706
Babbitt	Kinsey Houseboats	Lodging	2718 Birch River Rd	Babbitt	MN	55706
Babbitt	K & M Painting & Sandblasting	Painting	8267 Virginia Ely Rd	Babbitt	MN	55706
Babbitt	Timber Bay Lodge	Lodging	PO Box 248	Babbitt	MN	55706
Babbitt	Timber Bay Houseboats	Lodging	PO Box 248	Babbitt	MN	55706
Beaver Bay	Lemon Wolf Cafe	Food	711 MacDonald Ave	Beaver Bay	MN	55601
Beaver Bay	Camp 61 Bunkhouse, Restaurant, Coffee and Gifts	Lodging, Food, and Gifts	1017 Main Street	Beaver Bay	MN	55601
Beaver Bay	Cove Point Lodge	Lodging, Food	4614 Hwy 61	Beaver Bay	MN	55601
Beaver Bay	Beaver Bay Sport Shop	Sports equipment retail and rental	4878 Highway 61	Beaver Bay	MN	55601
Beaver Bay	Holiday Station Store	Gas	Hwy 61 & Old Town Rd	Beaver Bay	MN	55601
Beaver Bay	Mobil Mart	Gas	1022 Main Street	Beaver Bay	MN	55601
Beaver Bay	Beaver Bay Agate Shop	Gifts	1003 Main Street	Beaver Bay	MN	55601
Beaver Bay	The Cedar Chest	Gifts	1009 Main Street	Beaver Bay	MN	55601
Beaver Bay	Christmas Up North	Gifts	1009 Main Street	Beaver Bay	MN	55601
Beaver Bay	Shipwrecked Gift Shop	Gifts	1014 Main Street	Beaver Bay	MN	55601
Beaver Bay	Beaver Bay Sports Shop Inc	Sports Equipment	4878 Highway 61	Beaver Bay	MN	55601
Beaver Bay	Skipping Rock	Gifts	1017 Main Street	Beaver Bay	MN	55601
Beaver Bay	Big Dipper Ice Cream Shop	Ice Cream	Beaver Bay Mini Mall	Beaver Bay	MN	55601
Beaver Bay	Northern Lights Cafe/Roadhouse	Food	1040 Main St	Beaver Bay	MN	55601
Canada / Atikokan	Branch's Seine River Outfitters	Lodging and Outfitter	Banning Lake Rd	Atikokan	ON	P0T 1C0
Canada / Atikokan	Canoe Canada Canoe Outfitters	Canoe and Cabin Outfitter	300 O'Brien Street	Atikokan	ON	P0T 1C0
Duluth	Duluth Screen Printing	Clothing Co.	702 E 3rd St	Duluth	MN	55805
Duluth	Duluth Technology Co.	IT	12 E Superior St #6	Duluth	MN	55802
Duluth	Epicurean USA	Cutting Boards	257 B Main St, Superior	Superior	WI	54880
Duluth	Evolve Duluth	Yoga Studio	132 E Superior St	Duluth	MN	55802
Duluth	Great Lakes Fly Shop	Fly Shop	4426 Regent St	Duluth	MN	55804
Duluth	Intectural	Sustainable building materials	1325 N 59th Ave W	Duluth	MN	55807
Duluth	Lake Superior Art Glass	Art	202 E Superior St	Duluth	MN	55802
Duluth	Loll Designs	Furniture Designers	5912 Waseca St	Duluth	MN	55807
Duluth	Namebini	Fly Fishing Guide Service	2067 E Pioneer Rd	Duluth	MN	55804
Duluth	Neverest Outfitters	Clothing Co.	31 E 1st St	Duluth	MN	55802
Duluth	Natural Home	Construction	2525 S Lake Ave	Duluth	MN	55802
Duluth	North Shore Cottages	Hotel	7717 MN-61	Duluth	MN	55804
Duluth	Performance Edge	Wood Workers	5124 Beaver Creek Rd	Hermantown	MN	55811
Duluth	Red Herring Lounge	Bar/Lounge	208 E 1st St, Duluth	Duluth	MN	55802
Duluth	Stewart River Boatworks	Boats	196 Scenic Dr	Knife River	MN	55609

Duluth	SUPerior Paddle	Paddles		Duluth	MN	
Duluth	The Inn on Lake Superior	Hotel	350 Canal Park Dr	Duluth	MN	55802
Duluth	The Suites Hotel	Hotel	325 S Lake Ave	Duluth	MN	55802
Duluth	Canal Park Lodge	Hotel	250 Canal Park Dr	Duluth	MN	
Duluth	Sheraton Duluth Hotel	Hotel	301 E Superior St,	Duluth	MN	
Duluth	South Pier Inn	Hotel	701 S Lake Ave	Duluth	MN	
Duluth	Fitger's Inn	Hotel	600 E Superior St	Duluth	MN	
Duluth	Park Point Marina Inn	Hotel	1033 Minnesota Ave	Duluth	MN	
Duluth	Edgewater Inn and Waterpark	Hotel	2400 London Rd	Duluth	MN	
Duluth	Comfort Suites Canal Park	Hotel	408 Canal Park Dr	Duluth	MN	
Duluth	Fairfield Inn by Marriott	Hotel	901 Joshua Ave,	Duluth	MN	
Duluth	The Downtown Duluth Inn	Hotel	131 W 2nd St	Duluth	MN	
Duluth	Willard Munger Inn	Hotel	7408 Grand Ave	Duluth	MN	
Duluth	Voyageur Lakewalk Inn	Hotel	333 E Superior St	Duluth	MN	
Duluth	Pier B Resort	Hotel	800 W Railroad St	Duluth	MN	
Duluth	Beacon Pointe Resort	Hotel	2100 E Water St	Duluth	MN	
Duluth	A G Thomson House Bed and Breakfast	Bed and Breakfast	2617 E 3rd St	Duluth	MN	
Duluth	Solglimpt Bed and Breakfast	Bed and Breakfast	828 S Lake Ave	Duluth	MN	
Duluth	The Inn on Gitche Gume	Hotel	8517 Congdon Blvd	Duluth	MN	
Duluth	Ellery House Bed and Breakfast	Bed and Breakfast	28 S 21st Ave E	Duluth	MN	
Duluth	The Firelight Inn on Oregon Creek Bed and Breakfast	Bed and Breakfast	2211 E 3rd St	Duluth	MN	
Duluth	Cotton Mansion Bed and Breakfast	Bed and Breakfast	2309 E 1st St	Duluth	MN	
Duluth	Olcott House Bed and Breakfast Inn	Bed and Breakfast	2316 E 1st St	Duluth	MN	
Duluth	Allyndale Motel	Hotel	510 N 66th Ave W	Duluth	MN	
Duluth	Northshore Cottages	Hotel	7717 MN-61	Duluth	MN	
Duluth	Mountain Villas	Hotel	9525 W Skyline Pkwy	Duluth	MN	
Duluth	Gardenwood Resort and Motel	Hotel	5107 N Shore Dr	Duluth	MN	
Duluth	Cape Superior Inn	Hotel	5133 N Shore Dr,	Duluth	MN	
Duluth	Ski Hut	Ski and Bike Shop	1032 E 4th St	Duluth	MN	
Duluth	Duluth Kitchen Co.	Kitchen Goods	600 E Superior St	Duluth	MN	
Duluth	Trailfitters	Outfitting and outdoor goods	600 E Superior St # 105	Duluth	MN	
Duluth	The Red Door	Antiques and Gifts	720 E 4th St	Duluth	MN	
Duluth	Art in the Alley	Gifts	230 E Superior St	Duluth	MN	
Duluth	Duluth Trading Company	Clothing	300 E Superior St	Duluth	MN	
Duluth	Fannie Rose Candy Shop	Candy Shop	103 E Superior S	Duluth	MN	
Duluth	DLH Clothing	Clothing	10 E Superior St #202	Duluth	MN	
Duluth	Electric Fetus	Music, Gifts, Jewelry Shop	12 E Superior St	Duluth	MN	
Duluth	Lizzards Art Gallery and Framing	Gallery and Gifts	11 W Superior St	Duluth	MN	
Duluth	Duluth Pack Store	Packs, Clothing	365 Canal Park Dr	Duluth	MN	
Duluth	I Love Duluth	Clothing/Gifts	345 Canal Park Dr	Duluth	MN	
Duluth	Bella Flora Inc.	Floral Shop	138 W 1st St	Duluth	MN	
Duluth	Hepzibah's Sweet Shoppe	Candy Shop	394 S Lake Ave	Duluth	MN	

Duluth	Waters of Lake Superior	Jewelry/Art/Gifts	395 S Lake Ave #2	Duluth	MN	
Duluth	Minnesota Gifts by Sandra Dee	Jewelry/Art/Gifts	394 S Lake Ave #103	Duluth	MN	
Duluth	Blue Herron Trading Co.	Kitchen Goods	394 S Lake Ave #102	Duluth	MN	
Duluth	Frost River	Leather Goods/Bags	1910 W Superior St	Duluth	MN	
Duluth	Continental Ski & Bike	Ski and Bike Shop	1305 E First St	Duluth	MN	
Duluth	Sivviis	Jewelry/Art/Gifts	361 Canal Park Dr	Duluth	MN	
Duluth	Portland Malt Shoppe	Ice Cream	716 E Superior St	Duluth	MN	
Duluth	Namaste Gifts and Healing	Jewelry/Art/Gifts	400 W Superior St,	Duluth	MN	
Duluth	Johnson's Bakery and Coffee Shop	Bakery/Coffee	2230 W 3rd St	Duluth	MN	
Duluth	Duluth Running Co.	Running Company	1026 E Superior St	Duluth	MN	
Duluth	Shanty Bottle Shop	Liquor Store	1231 E 4th St, Duluth	Duluth	MN	
Duluth	Fitger's Brewhouse Beer Store	Beer Sales	600 E Superior St	Duluth	MN	
Duluth	Minnesota Surplus and Outfitters	Outfitting	218 W Superior St	Duluth	MN	
Duluth	Northern Waters Smokehaus	Smoked Meats	394 S Lake Ave #106,	Duluth	MN	55802
Duluth	Dick's Sporting Goods	Athletic Store	1600 Miller Trunk Hwy	Duluth	MN	
Duluth	Spirit Bay Trading Co.	Native Gifts	395 S Lake Ave #5	Duluth	MN	55802
Duluth	King of Creams	Icecream Shop	502 E 4th St,	Duluth	MN	
Duluth	Legacy Toys	Toyshop	1600 Miller Trunk Hwy	Duluth	MN	
Duluth	Caribou Coffee	Coffee Shop	307 Canal Park Dr	Duluth	MN	55802
Duluth	Amazing Grace Bakery	Bakery	394 S Lake Ave	Duluth	MN	55802
Duluth	Zenith Bookstore	Bookstore	318 N Central Ave,	Duluth	MN	
Duluth	Coldstone Creamery	Icecream Shop	349 Canal Park Dr	Duluth	MN	55802
Duluth	Old World Meats	Deli	226 S Basswood Ave	Duluth	MN	
Duluth	Global Village	Gifts/Clothing	501 S Lake Ave	Duluth	MN	55802
Duluth	Walgreens	Retail	1131 E Superior St	Duluth	MN	
Duluth	Cub Foods	Grocery	615 W Central Entrance	Duluth	MN	
Duluth	Mount Royal Fine Foods	Grocery	1600 Woodland Ave	Duluth	MN	
Duluth	Twin Ports Cyclery	Cycle Shop	2914 W 3rd St	Duluth	MN	
Duluth	Chilly Billy's Frozen Yogurt	Frozen Yogurt	1010 Woodland Ave	Duluth	MN	
Duluth	Rocky Mountain Chocolate	Chocolate shop	1600 Miller Trunk Hwy # 314	Duluth	MN	
Duluth	Toasty's	Grilled Cheese Shop	1032 E 9th St	Duluth	MN	
Duluth	Beaner's Central Coffeehouse	CoffeeShop	324 N Central Ave	Duluth	MN	
Duluth	Caribou Coffee and Einstein Bagels	Cafe/Coffeeshop	1515 Kenwood Ave Suite A,	Duluth	MN	
Duluth	Whole Foods Coop	Grocery	610 E 4th St	Duluth	MN	
Duluth	Bridgeman's	Icecream	2202 Mountain Shadow Dr	Duluth	MN	
Duluth	Duluth Pack Manufacturing	Manufacturing Co.	1610 W Superior St	Duluth	MN	
Duluth	Jacq Frost	Icecream	337 Canal Park Dr	Duluth	MN	
Duluth	Serendipidy	Giftshop	4407 E Superior St	Duluth	MN	
Duluth	Panera Bread	Cafe	2108 Maple Grove Rd	Duluth	MN	
Duluth	Cash Wise Liquor	Liquor Store	625 W Central Entrance	Duluth	MN	
Duluth	Lotus on the Lake	Gifts/Clothing	600 E Superior St,	Duluth	MN	
Duluth	Market Day Duluth	Gifts/Clothing	15 N 3rd Ave W	Duluth	MN	

Duluth	Super One	Grocery	5300 Bristol St	Duluth	MN	
Duluth	Vertical Endeavors	Climbing Wall	329 S Lake Ave	Duluth	MN	
Duluth	Ed Barbo's Columbia Clothing	Clothing	303 W Superior St	Duluth	MN	
Duluth	Super One	Grocery	5401 Burning Tree Rd	Duluth	MN	
Duluth	Gabriel's Bookstore	Bookstore	4915 E Superior St	Duluth	MN	
Duluth	Bookstore at Fitgers	Bookstore	600 E Superior St	Duluth	MN	
Duluth	J Skylark Co.	Toyshop	394 S Lake Ave	Duluth	MN	55802
Duluth	Duluth Timber Company	Timber Co.	1400 W Railroad St,	Duluth	MN	55802
Duluth	Shopko Duluth	Retail	801 W Central Entrance	Duluth	MN	
Duluth	Lake Air Bottle Shoppe	Liquor Store	2530 London Rd	Duluth	MN	55812
Duluth	Target	Retail	1902 Miller Trunk Hwy,	Duluth	MN	
Duluth	Pickwick Restaurant	Restaurant	508 E Superior St	Duluth	MN	
Duluth	Fitger's Brewhouse Brewery and Grille	Restaurant	600 E Superior St	Duluth	MN	55802
Duluth	Va Bene Caffee	Restaurant	734 E Superior St	Duluth	MN	55802
Duluth	Uncle Loui's Cafe	Cafe	520 E 4th St	Duluth	MN	
Duluth	Valentino's Vicino Lago	Restaurant	1400 London Rd	Duluth	MN	55805
Duluth	Restaurant 301	Restaurant	301 E Superior St	Duluth	MN	
Duluth	Blackwater Lounge	Bar/Restaurant	231 E Superior St	Duluth	MN	55802
Duluth	7 West Taphouse	Restaurant	7 W Superior St	Duluth	MN	
Duluth	Sir Benedict's Tavern on the Lake	Restaurant	805 E Superior St	Duluth	MN	
Duluth	Burrito Union	Restaurant	1332 E 4th St	Duluth	MN	55805
Duluth	Boat Club Restaurant	Restaurant	600 E Superior St	Duluth	MN	55802
Duluth	Mexico Lindo Restaurant	Restaurant	600 E Superior St #201	Duluth	MN	55802
Duluth	Huie's Chopsticks Inn	Restaurant	505 E 4th St	Duluth	MN	55805
Duluth	Northern Waters Smokehaus	Deli	394 S Lake Ave #10	Duluth	MN	55802
Duluth	Bellisio's Italian Restaurant & Wine Bar	Restaurant	405 S Lake Ave	Duluth	MN	55802
Duluth	Grandma's Saloon & Grill Canal Park	Restaurant	522 S Lake Ave	Duluth	MN	55802
Duluth	Canal Park Brewing Company	Restaurant	300 Canal Park Dr	Duluth	MN	55802
Duluth	Pizza Luce	Restaurant	11 E Superior St #100	Duluth	MN	55802
Duluth	Black Woods Grill & Bar	Restaurant	2525 London Rd	Duluth	MN	55812
Duluth	Carmody Irish Pub	Restaurant	308 E Superior St	Duluth	MN	55802
Duluth	Lark O' the Lake Cafe	Restaurant	231 E Superior St #100	Duluth	MN	55802
Duluth	Endion Station Public House	Restaurant	200 Lake Pl Dr	Duluth	MN	55802
Duluth	Tavern on the Hill	Restaurant	1102 Woodland Ave	Duluth	MN	55812
Duluth	Duluth Grill	Restaurant	118 S 27th Ave W	Duluth	MN	55806
Duluth	OMC Smokehouse	Restaurant	909 W Superior St	Duluth	MN	55806
Duluth	Hanabi Japanese Cuisine	Restaurant	110 N 1st Ave W	Duluth	MN	55802
Duluth	Chinese Dragon	Restaurant	108 E Superior St	Duluth	MN	55802
Duluth	Lake Avenue	Restaurant	394 S Lake Ave	Duluth	MN	55802
Duluth	The Silos, Restaurant And Bar	Restaurant	800 W Railroad St	Duluth	MN	55802
Duluth	Sala Thai	Restaurant	114 W 1st St,	Duluth	MN	55802
Duluth	Dubh Linn Brew Pub	Restaurant	109 W Superior St	Duluth	MN	55802

Duluth	JJ Astor Restaurant and Lounge	Restaurant	505 W Superior St	Duluth	MN	55802
Duluth	Little Angie's Cantina And Grill	Restaurant	11 East Buchanan Street	Duluth	MN	55802
Duluth	Cloud 9	Restaurant	308 S Lake Ave	Duluth	MN	55802
Duluth	Grizzly's Wood-fire Grill Canal Park	Restaurant	310 S Lake Ave	Duluth	MN	55802
Duluth	Vitta Pizza	Restaurant	307 Canal Park Dr	Duluth	MN	55802
Duluth	Sammy's Pizza & Restaurant	Restaurant	103 W 1st St	Duluth	MN	55802
Duluth	Red Lobster	Restaurant	301 S Lake Ave	Duluth	MN	55802
Duluth	India Palace	Restaurant	319 W Superior St	Duluth	MN	55802
Duluth	Green Mill Restaurant & Bar	Restaurant	340 S Lake Ave #1	Duluth	MN	55802
Duluth	Old Chicago Pizza and Taproom	Restaurant	327 S Lake Ave	Duluth	MN	55802
Duluth	Taste of Saigon	Restaurant	394 S Lake Ave #105	Duluth	MN	55802
Duluth	DQ Grill & Chill Restaurant	Restaurant	307 Canal Park Dr #3	Duluth	MN	55802
Duluth	Taco John's	Restaurant	1810 London Rd	Duluth	MN	55812
Duluth	SUBWAY® Restaurants	Restaurant	1931 London Rd,	Duluth	MN	55812
Duluth	The Sports Garden Canal Park	Restaurant	425 S Lake Ave	Duluth	MN	55802
Duluth	Famous Dave's Duluth	Restaurant	355 S Lake Ave	Duluth	MN	55802
Duluth	Perkins Restaurant & Bakery	Restaurant	2502 London Rd,	Duluth	MN	55812
Duluth	Wendy's	Restaurant	2220 London Rd,	Duluth	MN	55812
Duluth	Grandma's Saloon & Grill Miller Hill	Restaurant	2202 Maple Grove Rd	Duluth	MN	55811
Duluth	Clyde Iron Works	Restaurant	2920 W Michigan St	Duluth	MN	55806
Duluth	Olive Garden Italian Restaurant	Restaurant	901 Mall Dr	Duluth	MN	55811
Duluth	Lyric Kitchen · Bar	Restaurant	205 W Superior St	Duluth	MN	55802
Duluth	Texas Roadhouse	Restaurant	902 Mall Dr	Duluth	MN	55811
Duluth	New London Cafe	Restaurant	4721 E Superior St	Duluth	MN	55804
Echo Trail	Timber Wolf Point Resort	Lodging	7079 Echo Trail	Buyck	MN	55771
Ely	2nd Chance Consignments & Curiosities	Thrift Store/Gifts	145 E Chapman St	Ely	MN	55731
Ely	A Laundry Room Inc.	Laundry	428 E Sheridan St	Ely	MN	55731
Ely	A Stay Inn Ely	Lodging	112 W Sheridan St	Ely	MN	55731
Ely	A Taste Of Ely	Food	117 N Central Ave	Ely	MN	55731
Ely	Adventure Inn	Lodging	1145 E Sheridan St	Ely	MN	55731
Ely	Aj's Fastlube & Auto Repair	Automobile Repair	1815 E Sheridan St	Ely	MN	55731
Ely	All Day Builders Inc.	Construction	205 N Central Ave	Ely	MN	55731
Ely	All Phase Construction Inc.	Construction	PO Box 633	Ely	MN	55731
Ely	American Family Insurance	Insurance	1245 E Sheridan St	Ely	MN	55731
Ely	Amici's Event Center	Event Center	10 W Pattison St	Ely	MN	55731
Ely	Anderson, Scott DDS	Dental	33 E Chapman St	Ely	MN	55731
Ely	Anderson's Construction Services Inc.	Construction	1347 E Washington St	Ely	MN	55731
Ely	Anderson's Resort	Lodging	3133 Fireside Dr	Ely	MN	55731
Ely	The Appraisal Office, LLC	Realty	345 E Conan St	Ely	MN	55731
Ely	Arrowhead R.V. Resort	Lodging	2121 E Camp St	Ely	MN	55731
Ely	Ely's Art & Soul Gallery	Art	427 E Sheridan St	Ely	MN	55731
Ely	The Art Corner	Art	301 W. Sheridan St	Ely	MN	55731

Ely	Axe Men Cabin Care & Tree Service Inc.	Landscaping	30 N 9th Ave E	Ely	MN	55731
Ely	Babe's Bait And Tackle	Fishing	451 W Sheridan St	Ely	MN	55731
Ely	Bare Bones Studio	Interior Design	PO Box 196	Ely	MN	55731
Ely	Basswood Trails Guide Service and Wilderness Outfitters	Guide	1699 Koski Rd	Ely	MN	55731
Ely	Bare Feet Heating & Refrigeration	HVAC	2121 E Camp St	Ely	MN	55731
Ely	Bear Island Land Co., Inc.	Lodging/Realty	943 E Sheridan St	Ely	MN	55731
Ely	Ben's Tree Service	Landscaping	1702 W Chig-A-Big Rd	Ely	MN	55731
Ely	Lakeshore Liquor	Liquor	438 E Sheridan St	Ely	MN	55731
Ely	Big Lake Wilderness Lodge and Outfitters	Lodge/Outfitting	4988 Big Lake Road	Ely	MN	55731
Ely	Bill's Boat Storage	Boat Storage	1490 White Iron Road North	Ely	MN	55731
Ely	Blade Slayers	Landscaping	12 E. Beacon Hill Rd	Ely	MN	55731
Ely	Blissful Body by Stephanie	Massage	337 E Washington St	Ely	MN	55731
Ely	Blomberg's Cenex	Oil & Propane	46 W Sheridan St	Ely	MN	55731
Ely	Bloomer's Floral and Gift	Floral	501 E Sheridan St	Ely	MN	55731
Ely	Boathouse Brewpub and Restaurant	Brewery	47 E Sheridan St	Ely	MN	55731
Ely	Phillip Boes Trucking	Trucking	1204 Winton Rd	Ely	MN	55731
Ely	Boundary Waters Bank	Bank	601 E Sheridan St	Ely	MN	55731
Ely	Boundary Waters Builders	Construction	3630 Wildgate Rd	Ely	MN	55731
Ely	Boundary Waters Care Center	Assisted Living	200 W Conan St	Ely	MN	55731
Ely	Boundary Waters Canoe Adventures	Guide/Recreation	PO Box 327	Ely	MN	55731
Ely	Boundary Waters Guide Service	Guide	529 E Sheridan St	Ely	MN	55731
Ely	Boundary Waters Ice, Inc.	Ice	442 N 15th Ave E	Ely	MN	55731
Ely	Boundary Waters Journal	Media/Magazine	9396 Rocky Ledge Rd	Ely	MN	55731
Ely	Boundary Waters Outfitters	Guide/Outfitting	629 Kawishiwi Trail	Ely	MN	55731
Ely	Boundary Waters Septic Pumping	Plumbing	2212 Longstorff Rd	Ely	MN	55731
Ely	Brandau Plumbing & Heating, Inc.	Pumbing	1111 MN-169	Ely	MN	55731
Ely	Brandenburg Gallery	Art	11 E. Sheridan St	Ely	MN	55731
Ely	Mike Braun Construction	Construction	1590 Highway 1	Ely	MN	55731
Ely	Britton's Café Inc.	Food	5 E Chapman St	Ely	MN	55731
Ely	Motel Ely- Budget Host	Loding	1047 E Sheridan St	Ely	MN	55731
Ely	Burntside Electric	Electrician	1610 E Washington St	Ely	MN	55731
Ely	Burntside Lodge	Loding	2755 Burntside Lodge Rd	Ely	MN	55731
Ely	BWCA Getaway Cabins	Lodging	118 Sunset Rd	Ely	MN	55731
Ely	The Cabin	Gifts	120 E Sheridan St	Ely	MN	55731
Ely	Cadline Design	Architecture	PO Box 623	Ely	MN	55731
Ely	Camp Van Vac	Lodging	2714 Van Vac Rd	Ely	MN	55731
Ely	Camp Voyageur, Inc.	Youth Camp	709 Voyageur Rd	Ely	MN	55731
Ely	Canadian Border Outfitters	Outfitting	14635 Canadian Border Rd	Ely	MN	55731
Ely	Canadian Waters Outfitters	Outfitting	111 E Sheridan St	Ely	MN	55731
Ely	Canoe Capital Realty, LLC	Realty	203 E Sheridan St	Ely	MN	55731
Ely	Canoe Country Electric	Electrician	110 S 19th Ave E	Ely	MN	55731
Ely	Canoe Country Cabins, Outfitters, Campground	Outfitting	PO Box 30	Ely	MN	55731

Ely	Canoe Country Title	Realty	8 N Central Ave, Suite 1	Ely	MN	55731
Ely	Canoe On Inn	Lodging	110 N 2nd Ave W	Ely	MN	55731
Ely	Carefree Living	Assisted Living	140 S 2nd Ave W	Ely	MN	55731
Ely	Casey Peterson Landscaping	Landscaping	129 S 15th Ave E	Ely	MN	55731
Ely	Central Avenue Business Park LLC	Business Center	655 S Central Ave	Ely	MN	55731
Ely	Charles R. Zeugner CPA	Accounting	10 N 1st Ave E, Suite 204	Ely	MN	55731
Ely	Chilly Dogs Sled Dog Trips	Guide	1557 Esterberg	Ely	MN	55731
Ely	Chocolate Moose	Food	101 N Central Ave	Ely	MN	55731
Ely	Chris Perry Gallery	Photography	447 E Sheridan St	Ely	MN	55731
Ely	Cliff Wold's Canoe Trip Outfitters, Campground	Outfitting	1731 E Sheridan St	Ely	MN	55731
Ely	Code Plus Construction	Construction	9206 Birch Lake Rd	Ely	MN	55731
Ely	Country Financial	Insurance	540 E Sheridan St	Ely	MN	55731
Ely	County Line Dog Boarding And Grooming	Pet Care	114 Kawishiwi Trail	Ely	MN	55731
Ely	Crapola!	Snacks	16 N 1st Ave E	Ely	MN	55731
Ely	Creekridge Lodge	Lodging	1752 Creek Ridge Trail	Ely	MN	55731
Ely	Culbert Realty & Appraisal	Realty	820 E White St	Ely	MN	55731
Ely	Cunningham Electric, Inc.	Electrician	13445 Villa Road	Ely	MN	55731
Ely	Custom Cabin Rentals	Lodging	14663 Vosburgh Rd	Ely	MN	55731
Ely	Custom Theaters Of Ely	Interior Design	301 W Sheridan St	Ely	MN	55731
Ely	Carlson Wagonlit Travel	Transportation	720 Miners Dr	Ely	MN	55731
Ely	Dao Of Well Being	Wellness	132 E White St	Ely	MN	55731
Ely	Deer Ridge Resort	Lodging	444 Fernberg Rd	Ely	MN	55731
Ely	Dee's Bar and Lounge	Bar/Food	17 E Sheridan St	Ely	MN	55731
Ely	Defenbaugh Law Office	Legal Services	107 E Camp St, Ste 1	Ely	MN	55731
Ely	Docks On Wheels	Dock Construction	2195 Twin Lakes Rd	Ely	MN	55731
Ely	Dollar General	Convenience/Gift Store	303 W Sheridan St	Ely	MN	55731
Ely	Dorothy Molter Museum	Museum	PO Box 391	Ely	MN	55731
Ely	Eagle Point	Lodging	13192 Mushroom Island Rd	Ely	MN	55731
Ely	Echo Shores Resort	Lodging	1522 Echo Trail	Ely	MN	55731
Ely	Echo Trail Outfitters	Outfitting	3788 Fenske Lake Rd	Ely	MN	55731
Ely	Edward Jones	Financial Advisor	150 W Sheridan St	Ely	MN	55731
Ely	Ely Area Credit Union	Bank	2 E Chapman St	Ely	MN	55731
Ely	Ely Auto Service	Automobile Repair	1614 E Harvey	Ely	MN	55731
Ely	Ely Bloomenson Hospital	Hospital	328 W Conan St	Ely	MN	55731
Ely	Ely Bowling Center	Bowling	43 E Camp St	Ely	MN	55731
Ely	Ely Chiropractic Clinic	Chiropracter	247 E Chapman St	Ely	MN	55731
Ely	Ely D. Q. Grill And Chill	Food	1441 E Sheridan St	Ely	MN	55731
Ely	Ely Design Works	Media Design	9 E Chapman St	Ely	MN	55731
Ely	Ely Echo	News	15 E Chapman St	Ely	MN	55731
Ely	Ely Electric	Electrician	1543 Highway 1	Ely	MN	55731
Ely	Ely Fishing Guide Company LLC, The	Fishing/Guide	520 E Washington St	Ely	MN	55731
Ely	Ely Flower & Seed Store	Hardware Store & UHAUL (?)	145 W Camp St	Ely	MN	55731

Ely	Ely Folk School	Craft/Skills	209 E Sheridan St	Ely	MN	55731
Ely	Ely Garage Doors And Openers	Garage Doors	1321 Highway 120	Ely	MN	55731
Ely	Ely Golf Club	Golf	PO Box 507	Ely	MN	55731
Ely	Ely License Bureau, Inc.	DMV	17 E Chapman St	Ely	MN	55731
Ely	Ely Northland Market	Food/Groceries	1230 E Sheridan St	Ely	MN	55731
Ely	Ely Outdoors Company	Outfitting	528 E Sheridan St	Ely	MN	55731
Ely	Ely Safe Ride	Transportation (& Food)	700 E Sheridan St	Ely	MN	55731
Ely	Ely Shopper	Advertising	243 E Chapman St	Ely	MN	55731
Ely	Ely Shuttle	Transportation	118 Sunset Rd	Ely	MN	55731
Ely	Ely Speed Wash	Laundry	342 E Sheridan St #1	Ely	MN	55731
Ely	Ely Sportswear Inc.	Clothing Store	21 E Sheridan St	Ely	MN	55731
Ely	Ely Steak House	Food	216 E Sheridan St	Ely	MN	55731
Ely	Ely Surplus Store	Outfitting	129 N Central Ave	Ely	MN	55731
Ely	Ely Timberjay	News	P.O. Box 718	Ely	MN	55731
Ely	Ely Veterinary Clinic	Pet Care	318 E Miners Dr	Ely	MN	55731
Ely	Ely Vision & Optometry Ctr, P.C.	Eye Care	38 E Harvey St	Ely	MN	55731
Ely	<u>Elylodging.Com</u>	Lodging	1323 E Sheridan St	Ely	MN	55731
Ely	Elywear	Clothing Store	2 E Sheridan St	Ely	MN	55731
Ely	Ely's Old-Fashioned Candy	Gifts/Candy	228 E Sheridan St	Ely	MN	55731
Ely	Espland's Resort	Lodging	1540 Grant McMahon Blvd	Ely	MN	55731
Ely	Evergreen Construction	Construction	PO Box 747	Ely	MN	55731
Ely	Evergreen Cottage	Massage	146 E Chapman St	Ely	MN	55731
Ely	Evergreen Restaurant	Food	400 N Pioneer Dr	Ely	MN	55731
Ely	E-Z Excavating	Contracting	46 E Conan St	Ely	MN	55731
Ely	Family Dollar	Gifts/Convenience	1406 E Sheridan St	Ely	MN	55731
Ely	Fenske Lake Cabins	Lodging	3788 Fenske Lake Rd	Ely	MN	55731
Ely	Finn-Tastic Painter	Contracting/Painting	3031 Burntside Ridge Trail	Ely	MN	55731
Ely	Forest Concrete Products	Construction/Concrete	1715 E Sheridan St	Ely	MN	55731
Ely	Frandsen Bank And Trust	Bank	102 E Sheridan St	Ely	MN	55731
Ely	J Fletcher Freeman Attorney at Law	Law	323 E Sheridan St	Ely	MN	55731
Ely	Front Porch Coffee & Tea Company	Food	343 E Sheridan St	Ely	MN	55731
Ely	Frontier Communications	Business	22 E Sheridan St	Ely	MN	55731
Ely	Northland Blasting & Restoration	Construction	1534 Johnson Creek Dr	Ely	MN	55731
Ely	G Men ,Inc	Waste Transport	PO Box 269	Ely	MN	55731
Ely	Garden Lake Resort	Lodging	13705 Mill Rd	Ely	MN	55731
Ely	Gator's Grilled Cheese Emporium	Food	955 E Sheridan St	Ely	MN	55731
Ely	Gene Hicks Gourmet Coffee	Coffee	PO Box 223	Ely	MN	55731
Ely	Gerzin's Wood Wizards	Contractor	815 E Conan St	Ely	MN	55731
Ely	Goodwill	Thriftstore	40 N 2nd Ave E	Ely	MN	55731
Ely	Gracies Plant Works	Landscaping	1485 Grant McMahon Blvd	Ely	MN	55731
Ely	Grand Ely Lodge Hotel	Lodging	400 N Pioneer Rd	Ely	MN	55731
Ely	Grandmas House Day Care	Child Care	324 S 4th Ave E, Apt 1	Ely	MN	55731

Ely	Grand Slam Guide Service	Guide	9396 Rocky Ledge Rd	Ely	MN	55731
Ely	Greenstone Landscaping & Nursery	Landscaping	2331 Old Highway 169	Ely	MN	55731
Ely	Greg Mangold Construction	Construction	2034 E Sheridan St	Ely	MN	55731
Ely	Gruba Construction	Construction	13460 North Pine Rd	Ely	MN	55731
Ely	H & R Block	Accounting	25 S 2nd Ave E	Ely	MN	55731
Ely	Hand-Done T-Shirts	Clothing	15 E Sheridan Ave	Ely	MN	55731
Ely	Happy Days Nursery School	Child Care	PO Box 134	Ely	MN	55731
Ely	Hearthside Corner	Interior Design/Fire Places	1203 E Sheridan St	Ely	MN	55731
Ely	Heavy Metal Sports, LLC	Athletic Center	27 E Chapman St	Ely	MN	55731
Ely	Hegfors And Son Construction	Construction	1346 E Camp St	Ely	MN	55731
Ely	Henry's Shoe Repair	Clothing	PO Box 706	Ely	MN	55731
Ely	Highstone Glassworks	Art	138 W Conan St	Ely	MN	55731
Ely	Holiday	Gas Station	1036 E Sheridan St	Ely	MN	55731
Ely	Huisman Fine Woodworking	Construction	2027 Haapala Rd	Ely	MN	55731
Ely	Hunter Island Guide Service	Guide	1033 E Harvey Street	Ely	MN	55731
Ely	Minnsnowta Roof Razor	Roof Snow Removal	906 E White St	Ely	MN	55731
Ely	Insula Restaurant	Food	145 E Sheridan St	Ely	MN	55731
Ely	International Wolf Center	Wildlife Center	1396 Hwy 169	Ely	MN	55731
Ely	J & L Rental & Hardware Hank/Ben Franklin	Hardware Store	128 E Chapman St	Ely	MN	55731
Ely	J.D. Mills Company	Clothing	230 E Sheridan St	Ely	MN	55731
Ely	Jim The Fish Guy Guide Service	Guide	PO Box 553	Ely	MN	55731
Ely	Joe's Marine & Repair, Inc.	Marine Service	25 W Chapman St	Ely	MN	55731
Ely	Joni's Barkery	Pet Care	1253 E White St	Ely	MN	55731
Ely	Jordan's Canoe Outfitters	Outfitting	1701 Hwy 1	Ely	MN	55720
Ely	Jvm Photos	Photography	PO Box 333	Ely	MN	55731
Ely	Kabin Keepers	Lodging?	207 Sunset Rd	Ely	MN	55731
Ely	Kawishiwi Lodge	Lodging	3187 Fernberg Rd	Ely	MN	55731
Ely	Kerntz Funeral Home	Funeral Home	140 E Sheridan St	Ely	MN	55731
Ely	Kerntz Tv And Appliance	Appliances	140 E Sheridan St	Ely	MN	55731
Ely	Kess Gallery And Frame Shop	Art	130 E Sheridan St	Ely	MN	55731
Ely	Klun Law Firm	Law	1 E Chapman St	Ely	MN	55731
Ely	Kondos Outdoors	Outfitting	205 N Central Ave	Ely	MN	55731
Ely	Kovall Construction	Construction	906 E Harvey St	Ely	MN	55731
Ely	Kuehls Logging	Logging	1565 Hwy 1	Ely	MN	55731
Ely	Kwazy Wabbit	Bar	11 N Central Ave	Ely	MN	55731
Ely	Lady Bug Lodge	Lodging	2279 Grant McMahon Blvd	Ely	MN	55731
Ely	La Gringa Design	Design	1940 Hwy 169	Ely	MN	55731
Ely	Lakehomes.Com Realty	Realty	14525 Snowbank Beach Rd	Ely	MN	55731
Ely	Land Of Lakes Insurance	Insurance	240 W Sheridan St	Ely	MN	55731
Ely	Lakeland Motel	Lodging	1403 E Sheridan St	Ely	MN	55731
Ely	Louis Champpa's Boundary Waters Taxidermy	Taxidermy	1237 E Sheridan St	Ely	MN	55731
Ely	Latourell's Resort	Lodging	14793 Moose Lake Rd	Ely	MN	55731
Ely	Latourell's Outfitters	Outfitting	PO Box 239	Ely	MN	55731
Ely	Leaning Cedar Tree Cabin	Lodging	1145 E Sheridan St	Ely	MN	55731

Ely	Legacy Toys	Gifts	5 N Central Ave	Ely	MN	55731
Ely	Listening Point Foundation	Outdoor Retreat	PO Box 180	Ely	MN	55731
Ely	Lodge Of Whispering Pines	Lodging	PO Box 327	Ely	MN	55731
Ely	Log Cabin Coffee	Coffee	1340 E Sheridan St	Ely	MN	55731
Ely	Log Cabin Hideaways	Lodging	3013 Fernberg Trail	Ely	MN	55731
Ely	Loony's Northwoods Emporium	Gifts	16 W Sheridan St	Ely	MN	55731
Ely	Low Impact Excavators	Excavation	145 E Chapman St	Ely	MN	55731
Ely	Lutefisk Technologies, Inc	IT	114 E Boundary St	Ely	MN	55731
Ely	Mac Electric	Electrical Contracting	221 E Conan St	Ely	MN	55731
Ely	Manko, Craig R Electric	Electrical Contracting	45 N Klondike Dr	Ely	MN	55731
Ely	Mealey's Gift & Sauna Shop	Gifts	124 N Central Ave	Ely	MN	55731
Ely	Merhar's Ace Hardware	Hardware Store	48 E Chapman St	Ely	MN	55731
Ely	Mike Motors Of Minnesota, Inc.	Automotive	908 E Sheridan St	Ely	MN	55731
Ely	Mike's Liquors	Liquor	401 E Sheridan St	Ely	MN	55731
Ely	Moose Bay Company	Guide/Fishing	14624 Moose Bay Rd	Ely	MN	55731
Ely	Moose Track Adventures Guide Service, Campground	Outfitting	593 Kawishiwi Trail	Ely	MN	55731
Ely	Moose Track Adventures Resort	Lodging	593 Kawishiwi Trail	Ely	MN	55731
Ely	Mostly Moose & More	Gifts	8 E Sheridan St	Ely	MN	55731
Ely	Murphy's Paint Service	Painting	2634 Van Vac Rd	Ely	MN	55731
Ely	Napa Parts Center, Inc.	Automotive	45 E Chapman St	Ely	MN	55731
Ely	Nickerson Construction	Construction	2032 Chippewa Shores	Ely	MN	55731
Ely	Norshor Agency, Inc	Insurance	628 E Sheridan St	Ely	MN	55731
Ely	North American Bear Center	Wildlife Center	1926 Hwy 169	Ely	MN	55731
Ely	North Country Canoe Outfitter	Outfitting	474 Kawishiwi Trail	Ely	MN	55731
Ely	North Ridge Community Credit Union	Bank	1321 E Sheridan St	Ely	MN	55731
Ely	Northeast Title Company	Insurance	41 E Camp St	Ely	MN	55731
Ely	Northern Expressions	Food	48 E Sheridan St	Ely	MN	55731
Ely	Northern Grounds	Coffee	2 W Sheridan St	Ely	MN	55731
Ely	Northern Lakes Arts Association	Art	1900 E Camp St	Ely	MN	55731
Ely	Northern Lights Lodge	Lodging	PO Box 328	Ely	MN	55731
Ely	Northern Routes Roll-Off	Waste Transport	128 E Sheridan St	Ely	MN	55731
Ely	Northern Tier High Adventure	Youth Camp	14790 Moose Lake Rd	Ely	MN	55731
Ely	Northernair Lodge	Lodging	2130 Walleye Way	Ely	MN	55731
Ely	Northland Builders	Construction	PO Box 715	Ely	MN	55731
Ely	Northland Creations	Gifts	1229 E Sheridan St	Ely	MN	55731
Ely	Northwind Lodge	Lodging	2267 Fernberg Rd	Ely	MN	55731
Ely	Northwoods Collision Center	Automotive	1140 E Main St	Ely	MN	55731
Ely	Northwoods Partners	Senior Care	328 W Conan St	Ely	MN	55731
Ely	O'Conner Consulting	IT	134 N 1st Ave E	Ely	MN	55731
Ely	OJ's HVAC & Refrigeration	HVAC	2552 Hwy 169	Ely	MN	55731
Ely	Omega Point Multi Media & Design	Media Design	132 E White St	Ely	MN	55731
Ely	Organic Roots	Food	141 E Chapman St	Ely	MN	55731
Ely	Oriental Orchid	Food	506 E Sheridan St	Ely	MN	55731
Ely	Oxley Painting Joseph	Painting	13434 N Pine Rd	Ely	MN	55731
Ely	Packsack Log Cabins	Lodging	PO Box 780	Ely	MN	55731
Ely	Paddle Inn	Lodging	1314 E Sheridan St	Ely	MN	55731
Ely	Pebble Spa	Spa	229 E Sheridan St	Ely	MN	55731
Ely	Pengal's Basswood Trading	Gifts/Outfitting	137 E Sheridan St	Ely	MN	55731
Ely	Peshel Accounting	Accounting	PO Box 89	Ely	MN	55731

Ely	Phelps Chiropractic Clinic	Wellness	22 E Chapman St	Ely	MN	55731
Ely	Phil's Cars	Automobile Repair	3670 Hwy 169	Ely	MN	55731
Ely	Pinckney Construction	Construction	464 Ernies Rd	Ely	MN	55731
Ely	Pine Manor	Housing/Lodging	1421 E Camp St #7	Ely	MN	55731
Ely	Pine Point Lodge	Lodging	474 Kawishiwi Trail	Ely	MN	55731
Ely	Piragis Northwoods Store and Outfitters	Outfitting	105 N Central Ave	Ely	MN	55731
Ely	PJ's Hair Company	Hair Salon	1309 E Sheridan St	Ely	MN	55731
Ely	Play House 2 Day Care	Child Care	710 & 714 E Madison St	Ely	MN	55731
Ely	Plum Bun Bakery	Food	402 E Sheridan St	Ely	MN	55731
Ely	Portage Pizza	Food	942 E Pattison St	Ely	MN	55731
Ely	Porthan Painting	Painting	PO Box 187	Ely	MN	55731
Ely	Pottery Shop	Gifts	127 E Sheridan St	Ely	MN	55731
Ely	Power Maid	Cleaning Service	343 E Harvey St	Ely	MN	55731
Ely	Quality Kennels	Pet Care	1505 Hendrickson Rd	Ely	MN	55731
Ely	R & R Transfer	Hauling	420 N 15th Ave E	Ely	MN	55731
Ely	Range LP Gas	Oil & Propane	1613 E Camp St	Ely	MN	55731
Ely	Raven Productions	Book Publishing	PO Box 188	Ely	MN	55731
Ely	Razor Edge Systems	Knife Sharpening	303 17th Ave E	Ely	MN	55731
Ely	Red Cabin Custard	Food	1114 E Sheridan St	Ely	MN	55731
Ely	Red Rock Store	Outfitting	PO Box 690	Ely	MN	55731
Ely	Reedy Auction Service	Auctions	529 E Washington St	Ely	MN	55731
Ely	Rest Easy Cabin Care & Construction	Construction	245 E Boundary St	Ely	MN	55731
Ely	Retreats On White Iron Lake	Lodging	13496 Pine Road	Ely	MN	55731
Ely	River Point Resort and Outfitters	Lodging/Outfitting	PO Box 397	Ely	MN	55731
Ely	River Point Chalets And Villas	Lodging	PO Box 397	Ely	MN	55731
Ely	Riverside Resort & Island Campsites	Lodging/Camping	464 Ernie's Rd	Ely	MN	55731
Ely	Rockwood Bar & Grill Of Ely, Inc.	Food	302 E Sheridan St	Ely	MN	55731
Ely	Roots Salon	Salon	129 E Sheridan St	Ely	MN	55731
Ely	Ruscus Plumbing And Heating	Plumbing	1640 Highway 1	Ely	MN	55731
Ely	Samz Bar	Bar	1225 Winton Rd	Ely	MN	55731
Ely	Schulze Excavating, Inc	Construction	2408 Hwy 169	Ely	MN	55731
Ely	Serena's Carpet Shop	Interior Design/Carpet	114 E Chapman St	Ely	MN	55731
Ely	ServiceMaster Clean	Cleaning Service	PO Box 747	Ely	MN	55731
Ely	Shagawa Inn Motel, Resort & Campgrounds	Lodging	1973 W Shagawa Rd	Ely	MN	55731
Ely	Shagawa Lake Marina	Marina	2068 Highway 169	Ely	MN	55731
Ely	Shopko Hometown	Homegoods Store	1500 E Sheridan St	Ely	MN	55731
Ely	Shoreline Realty, Inc.	Realty	2080 Mollywood Ln	Ely	MN	55731
Ely	Silver Birch Builders	Construction	206 E White St	Ely	MN	55731
Ely	Silver Rapids Campground	Camping	459 Kawishiwi Trail	Ely	MN	55731
Ely	Silver Rapids Hotel	Lodging	459 Kawishiwi Trail	Ely	MN	55731
Ely	Silver Rapids Lodge Resort	Lodging	459 Kawishiwi Trail	Ely	MN	55731
Ely	Singing River Publications Inc.	Book Publishing	3365 Wolf Lake Rd	Ely	MN	55731
Ely	Sir G Restaurant	Food	520 E Sheridan St	Ely	MN	55731
Ely	Sisu Designs Yarn Shop	Gifts/Yarn	31 W Chapman St	Ely	MN	55731
Ely	Sjoberg Masonry	Contractor	19 W Harvey St	Ely	MN	55731
Ely	Skubes Bait & Tackle	Fishing	1810 E Sheridan St	Ely	MN	55731
Ely	Smitty's On Snowbank	Lodging	14564 Snow Lodge Rd	Ely	MN	55731
Ely	Specialty Commercial & Residential Cleaning	Cleaning Service	1317 N Highway 21	Ely	MN	55731
Ely	Spirit Of The Wilderness Store, Outfitters	Outfitting	2030 E Sheridan St	Ely	MN	55731

Ely	Starkman Oil Co.	Music	1842 E Sheridan St	Ely	MN	55731
Ely	State Farm Insurance	Insurance	35 E Chapman St	Ely	MN	55731
Ely	Steger Mukluks	Footwear	33 E Sheridan St	Ely	MN	55731
Ely	Stone Soup Events	Party Planning	229 E Sheridan St	Ely	MN	55731
Ely	Stony Ridge On Shagawa Lake	Lodging/Food	60 W Lakeview Pl	Ely	MN	55731
Ely	Studio North-Dance & Fitness Ctr	Wellness	1550 E Washington St	Ely	MN	55731
Ely	Subway of Ely	Food	1520 E Sheridan St	Ely	MN	55731
Ely	Sunrise Cabin Care & Construction	Construction	1319 N Hwy 21	Ely	MN	55731
Ely	Super 8 Of Ely	Lodging	1605 E Sheridan St	Ely	MN	55731
Ely	Swanson Construction	Construction	PO Box 57	Ely	MN	55731
Ely	Sweet Fern Soap Company	Gifts/Soap	709 Voyageur Rd	Ely	MN	55731
Ely	Tamarack Resort	Lodging	3499 Tamarack Rd	Ely	MN	55731
Ely	Tandem Moose Builders, Inc.	Construction	3547 Victoria St	Ely	MN	55731
Ely	Ten80 North/Zig's Design	Web Design	1005 E Chapman St	Ely	MN	55731
Ely	Thrivent Financial	Finance	420 E Sheridan St	Ely	MN	55731
Ely	Timber Trail Lodge	Lodging	629 Kawishiwi Trail	Ely	MN	55731
Ely	Timber Trail Motel	Lodging	629 Kawishiwi Trail	Ely	MN	55731
Ely	Timber Wolf Lodge	Lodging	9130 Escape Rd	Ely	MN	55706
Ely	Timber Wolf RV Campground	Camping	9130 Escape Rd	Ely	MN	55706
Ely	Tim's Truck and Auto Inc.	Automobile Repair	46 W Camp St	Ely	MN	55731
Ely	Tisovich Trucking and Excavating	Excavation	1004 E Harvey St	Ely	MN	55731
Ely	Tofte Lake Center At Norms Fish Camp	Art/Lodging	2209 Fernberg Road	Ely	MN	55731
Ely	Tony's Conoco & Towing	Automobile Repair	3 E Sheridan St	Ely	MN	55731
Ely	Tranquility Wellness Center LLC	Wellness	244 W Sheridan St	Ely	MN	55731
Ely	Trembath's Machine & Welding	Machine Services	2110 E Sheridan St	Ely	MN	55731
Ely	True North Consultants	Business Development	737 S 5th Ave E	Ely	MN	55731
Ely	Two Hearts One River Massage	Massage	24 W Chapman St	Ely	MN	55731
Ely	USFS-Kawishiwi District	Wildlife Center/Recreation	1393 Hwy 169	Ely	MN	55731
Ely	Vermilion Community College	Education	1900 E Camp St	Ely	MN	55731
Ely	Veterans On The Lake Resort	Resort	161 Fernberg Rd	Ely	MN	55731
Ely	Voltz Technologies	IT	410 E Sheridan St	Ely	MN	55731
Ely	Voyageur Lumber	Lumber	101 W Sheridan St	Ely	MN	55731
Ely	Voyageur North Outfitters	Outfitting	1829 E Sheridan St	Ely	MN	55731
Ely	Voyageur Outward Bound School	Education	1007 Spruce Rd	Ely	MN	55731
Ely	Voyageurs Short Stop	Convenience Store	1815 E Sheridan St	Ely	MN	55731
Ely	VP's Portable Toilets	Waste Transport	2208 MN-1	Ely	MN	55731
Ely	Walsh Sewer and Septic Systems	Septic Services	13964 Lauder Ave	Ely	MN	55796
Ely	Warren Johnson Logging, Inc.	Logging	1003 S 2nd Ave E	Ely	MN	55731
Ely	Way To Go Outfitters	Outfitting	1557 Esterberg Rd	Ely	MN	55731
Ely	Webgoddess.Net	Web Design	1238 E Washington St	Ely	MN	55706
Ely	Wee Cabin Company	Construction/Lodging	PO Box 746	Ely	MN	55731
Ely	Wells Fargo Bank	Bank	104 E Chapman St	Ely	MN	55731
Ely	WELY	Radio	133 E Chapman St	Ely	MN	55731
Ely	Whispering Pines Campground	Camping	PO Box 327	Ely	MN	55731
Ely	White Iron Beach Resort	Lodging/Fishing	13471 White Iron Beach Rd	Ely	MN	55731
Ely	White Wolf Dog Sled Trips	Guide	2141 Hwy 1	Ely	MN	55731
Ely	Wilderness Bay Lodge	Lodging	3424 Snowbank Lake Rd	Ely	MN	55731
Ely	Wildlife Liquor	Liquor	25 N 1st Ave E	Ely	MN	55731
Ely	Wildlife Treasures	Gifts	2301 Echo Trail	Ely	MN	55731

Ely	Wild Within	Day care	1305 E Harvey St	Ely	MN	55731
Ely	Wildwoods Land Company	Realty	1325 E Sheridan St	Ely	MN	55731
Ely	Williams & Hall Wild. Guides & Outfitters	Guide/Outfitting	14694 Vosburgh Rd	Ely	MN	55731
Ely	Wintergreen Lodge	Guide/Lodging	1101 Ring Rock Road	Ely	MN	55731
Ely	Wintergreen Northern Wear	Clothing	205 E Sheridan St	Ely	MN	55731
Ely	W N Plumbing & Heating	Plumbing/Heating	203 E Conan St	Ely	MN	55731
Ely	Wolfland Computers	IT	423 E Sheridan St #2	Ely	MN	55731
Ely	Wolftrack Classic	Festival	PO Box 76	Ely	MN	55731
Ely	YMCA Camp Du Nord	Family Camp	3606 North Arm Rd	Ely	MN	55731
Ely	Zaverl's Bar	Bar	509 E Sheridan St	Ely	MN	55731
Ely	Zone 3 Gardens	Landscaping/Art	386 Garden Lake Rd	Ely	MN	55731
Ely	Zupancich Trucking, Inc	Trucking	1118 S 3rd Ave E	Ely	MN	55731
Ely	Zup's Food Market	Food	303 E Sheridan St	Ely	MN	55731
Ely	Z'up North Realty	Realty	424 E Sheridan St	Ely	MN	55731
Grand Marais	Joynes Ben Franklin	Store	105 Wisconsin St. PO Box 430	Grand Marais	MN	55604
Grand Marais	Blue Water Cafe	Cafe	20 West Wisconsin Street PO Box 302		MN	55604
Grand Marais	Sydney's Frozen Custard & Wood-Fired Pizza	Summer Restaurant	14 South Broadway	Grand Marais	MN	55604
Grand Marais	Cook County Whole Foods Co-op	Grocery	20 East 1st St PO Box 813	Grand Marais	MN	55604
Grand Marais	Dockside Fish Market	Market/Cafe	418 W Hwy 61 PO Box 921	Grand Marais	MN	55604
Grand Marais	Java Moose Espresso	Cafe	218 W Hwy 61	Grand Marais	MN	55604
Grand Marais	Angry Trout Cafe	Restaurant	408 W Hwy 61	Grand Marais	MN	55604
Grand Marais	My Sister's Place	Restaurant	401 E Hwy 61	Grand Marais	MN	55604
Grand Marais	Harbor House Grille	Restaurant	411 W Hwy 61	Grand Marais	MN	55604
Grand Marais	Crooked Spoon Cafe	Restaurant	17 West Wisconsin Street,	Grand Marais	MN	55604
Grand Marais	Hughie's Taco House	Restaurant	15 W Hwy 61	Grand Marais	MN	55604
Grand Marais	Gunflint Tavern	Restaurant	111 W Wisconsin St,	Grand Marais	MN	55604
Grand Marais	Grandma Ray's	Restaurant	19 1st Ave W	Grand Marais	MN	55604
Grand Marais	Voyageur Brewing Company	Brewhouse	233 W Hwy 61	Grand Marais	MN	55604
Grand Marais	Birch Terrace Supper Club	Restaurant	601 MN-61	Grand Marais	MN	55604
Grand Marais	Pickled Herring Club	Restaurant	9 Wisconsin St,	Grand Marais	MN	55604
Grand Marais	Skyport Lodge & Raven Rock Grill	Restaurant/Lodge	205 Fireweed Ln	Grand Marais	MN	55604
Grand Marais	Sven and Ole's Pizza	Restaurant	9 Wisconsin St	Grand Marais	MN	55604
Grand Marais	Best Western Plus Superior Inn	Hotel	104 1st Ave. E	Grand Marais	MN	55604
Grand Marais	The Shoreline Inn	Hotel	20 South Broadway Avenue,	Grand Marais	MN	55604
Grand Marais	The Aspen Inn	Hotel	1711 W Hwy 61	Grand Marais	MN	55604
Grand Marais	East Bay Suites	Hotel	21 Wisconsin St,	Grand Marais	MN	55604
Grand Marais	The Aspen Lodge	Hotel	208 East Highway 61,	Grand Marais	MN	55604
Grand Marais	The Harbor Inn	Hotel	207 Wisconsin St	Grand Marais	MN	55604
Grand Marais	The Mangy Moose Motel	Hotel	202 1st Ave E	Grand Marais	MN	55604
Grand Marais	Feather Nest Inn	Hotel	101 5th Ave W	Grand Marais	MN	55604
Grand Marais	Nelson's Travelers Rest Cabins and Motel	Hotel	1300 MN-61	Grand Marais	MN	55604
Grand Marais	Trailside Cabins and Motel	Hotel	1100 MN-61	Grand Marais	MN	55604
Grand Marais	MacArthur House Bed and Breakfast	Bed and Breakfast	520 W 2nd St	Grand Marais	MN	55604
Grand Marais	Ella's Inn	Hotel	118 3rd Ave W	Grand Marais	MN	55604
Grand Marais	Spruceglen Inn	Hotel	218 MN-61	Grand Marais	MN	55604
Grand Marais	Russell's Cottages and Motel	Hotel	20 5th Ave W	Grand Marais	MN	55604
Grand Marais	Pincushion Trails Inn Bed and Breakfast	Hotel	968 Gunflint Trail	Grand Marais	MN	55604
Grand Marais	Terrace Point	Hotel	208 East Highway 61	Grand Marais	MN	55604
Grand Marais	Thomsonite Beach Inn and Suites	Hotel	2920 W Hwy 61	Grand Marais	MN	55604

Grand Marais	Outpost Motel	Hotel	2935 MN-61	Grand Marais	MN	55604
Grand Marais	The Hungry Hippy Farm & Hostel	Hostel	401 Co Rd 14	Grand Marais	MN	55604
Grand Marais	Lake Superior Trading Post	Gifts/ Book Store	10 S. 1st Ave W	Grand Marais	MN	55604
Grand Marais	Gunflint Mercantile	Store	12 1st Ave W	Grand Marais	MN	55604
Grand Marais	Upstate MN	Store	16 1st Ave W	Grand Marais	MN	55604
Grand Marais	Stone Harbor Wilderness Supply	Outdoor gear Store	22 E, 1st S	Grand Marais	MN	55604
Grand Marais	White Pine North	Gifts/Store	15 W Wisconsin Street	Grand Marais	MN	55604
Grand Marais	Sivertson Gallery	Gallery/Store	14 W. Wisconsin St	Grand Marais	MN	55604
Grand Marais	Beth's Fudge & Gifts	Candy Store	11 Broadway	Grand Marais	MN	55604
Grand Marais	The Market	Gifts/Clothing	3 Wisconsin St	Grand Marais	MN	55604
Grand Marais	The Blue Moose	Store	1301 W Hwy 61	Grand Marais	MN	55604
Grand Marais	That Little Red House	Yarn Store	113 1st Ave W	Grand Marais	MN	55604
Grand Marais	Birchbark Books & Gifts	Gifts/BookStore	11 1st Ave W	Grand Marais	MN	55604
Grand Marais	Drury Lane Books	BookStore	12 Wisconsin St	Grand Marais	MN	55604
Grand Marais	Fireweed Bike Cooperative	Bike Shop	13 Broadway,	Grand Marais	MN	55604
Grand Marais	Beaver House	Fishing Shop	3E Wisconsin St	Grand Marais	MN	55604
Grand Marais	Terra Bella Floral	Florist	407 4th Ave. EAST, PO Box 114	Grand Marais	MN	55604
Grand Marais	Johnson's Foods	Grocery	5 MN-61	Grand Marais	MN	55604
Grand Marais	Gene's Foods	Grocery	431 East Highway 61,	Grand Marais	MN	55604
Grand Marais	Moose Tracks	Gift Shop	w, 5 Wisconsin St	Grand Marais	MN	55604
Grand Marais	World's Best Donuts	Donuts/Cafe	10 Wisconsin St,	Grand Marais	MN	55604
Grand Marais	Joy & Company	Art Galler/Gifts	16 1st Ave W	Grand Marais	MN	55604
Grand Marais	First & Second Thrift Store	Thrift Shop	211 W Hwy 61	Grand Marais	MN	55604
Grand Marais	Shirt Outfitters	Clothing Shop	10 S 1st Ave W	Grand Marais	MN	55604
Grand Marais	Grand Marais Rock Shop	Gift Store	1821 W Hwy 61	Grand Marais	MN	55604
Grand Marais	Pinic & Pine	Gift Shop	19 Wisconsin St,	Grand Marais	MN	55604
Grand Marais	Northhouse Folk School	Northern Craft Learning Center	500 MN-61	Grand Marais	MN	55604
Grand Marais	Grand Marais Glass Shop LLC	Blown Glass Shop	18 1st Ave W	Grand Marais	MN	55604
Grand Marais	Bear Track Outfitting Co. and Bally Creek Cabins and Fishin'	Outfitter	2011 W Hwy 61	Grand Marais	MN	55604
Grand Marais	Devil's Track Nordic Ski Shop	Ski Shop	922 Gunflint Trail	Grand Marais	MN	55604
Grand Marais	Putt n Pets Mini Golf	Miniature Golf	2014 MN-61	Grand Marais	MN	55604
Grand Marais	Stephan Hoglund Jewelry Design/ Superior Design Jewelry	Jewelry Store	301 1st Ave W	Grand Marais	MN	55604
Grand Marais	Cabin Antiques	Antique Store	3W7TH AVE	Grand Marais	MN	55604
Grand Marais	Devils Track General Store	General Store	2 Thompson Park Dr	Grand Marais	MN	55604
Grand Marais	Trout Lake Resort	Lodging	789 Trout Lake Rd	Grand Marais	MN	55604
Grand Marais	Ugly Baby Bait and Boats	Bait, fishing, and novelty store	7587 Gunflint Trail	Grand Marais	MN	55604
Grand Marais	Taiga Design+Build	Builders	PO Box 1428	Grand Marais	MN	55604
Gunflint Trail	Way of the Wilderness Canoe	Lodge	12582 Gunflint Trail	Grand Marais	MN	55604
Gunflint Trail	Chikwauk	Lodge/Museum	28 Moose Pond Dr	Grand Marais	MN	55604
Gunflint Trail	Tuscarora Lodge & Canoe Outfitters	Outfitter	193 Round Lake Rd	Grand Marais	MN	55604
Gunflint Trail	Cross River Lodge	Lodge	196 N Gunflint Lake Rd	Grand Marais	MN	55604
Gunflint Trail	Hungry Jack Outfitters	Outfitter	318 S Hungry Jack Rd	Grand Marais	MN	55604
Gunflint Trail	Hungry Jack Lodge & Campground	Lodge	372 Hungry Jack Rd	Grand Marais	MN	55604
Gunflint Trail	Trail Center	Restaurant	7611 Gunflint Trail,	Grand Marais	MN	55604
Gunflint Trail	Clearwater BWCA Outfitters	Outfitter	772 Clearwater Rd.	Grand Marais	MN	55604
Gunflint Trail	Clearwater Historic Lodge & Canoe Outfitters	Outfitter	774 Clearwater Rd	Grand Marais	MN	55604
Gunflint Trail	Bearskin Lodge	Lodge	124 E Bearskin Rd	Grand Marais	MN	55604
Gunflint Trail	East Bearskin Lake Campground	Campground	124 E Bearskin Rd	Grand Marais	MN	55604
Gunflint Trail	Golden Eagle Lodge	Lodge	468 Clearwater Rd	Grand Marais	MN	55604

Gunflint Trail	Gunflint Lodge & Canoe Outfitters	Outfitter	143 S Gunflint Lake Rd	Grand Marais	MN	55604
Gunflint Trail	Gunflint Northwoods Outfitters	Outfitter	143 S Gunflint Lake Rd	Grand Marais	MN	55604
Gunflint Trail	Heston's Lodge & Country Store	Lodge/Shop	579 S Gunflint Lake Rd	Grand Marais	MN	55604
Gunflint Trail	Loon Lake Lodge	Lodge	65 Loon Lake Road	Grand Marais	MN	55604
Gunflint Trail	Iron Lake Campground	Campground	Old Gunflint Trail	Grand Marais	MN	55604
Gunflint Trail	Rockwood Lodge & Outfitters	Lodge/Outfitter	50 Rockwood Rd	Grand Marais	MN	55604
Gunflint Trail	Nor'Wester Lodge	Lodge	7778 Gunflint Trail	Grand Marais	MN	55604
Gunflint Trail	Seagull Canoe Outfitters	Outfitter	12208 Gunflint Trail	Grand Marais	MN	55604
Gunflint Trail	Voyageur Canoe Outfitters and Cabins	Outfitter	189 Sag Lake Trail	Grand Marais	MN	55604
Gunflint Trail	Gunflint Pines Resort Cabins & Lakeshore Campground	Lodge	217 S Gunflint Lake Rd	Grand Marais	MN	55604
Gunflint Trail	Seagull & Saganaga Lake Cabins	Cabins	12208 Gunflint Trail	Grand Marais	MN	55604
Gunflint Trail	Loon House	Gift Shop	429 Gunflint Trail	Grand Marais	MN	55604
Hermantown	Walmart Supercenter	Retail	4740 Mall Dr	Hermantown	MN	55811
Hermantown	Mills Fleet Farm	Retail	4165 Loberg Ave	Hermantown	MN	55811
Hermantown	Super One	Grocery	5698 Miller Trunk Hwy	Duluth	MN	
Isabella	White Wilderness Sled Dog Adventures	Guide	Deep Lake Road	Isabella	MN	55607
Isabella	Snowshoe Country Lodge	Lodging	1350 Snowshoe Trail	Isabella	MN	55607
Lutsen	Eagle Ridge Resort at Lutsen Mountains	Lodging	445 Ski Hill Road	Lutsen	MN	55612
Lutsen	Papa Charlie's Restaurant and Tavern	Food	467 Ski Hill Road	Lutsen	MN	55612
Lutsen	Lutsen Mountains	Lodging and Skiing	467 Ski Hill Road	Lutsen	MN	55612
Lutsen	Lutsen Resort	Lodging	5700 MN-61	Lutsen	MN	55612
Lutsen	Lockport Marketplace and Deli	Food	1273 Highway 61	Lutsen	MN	55612
Lutsen	Fika Coffee	Coffee Shop	5327 Highway 61	Lutsen	MN	55612
Lutsen	Moguls	Food	371 Ski Hill Rd.	Lutsen	MN	55612
Lutsen	Poplar River Pub	Food	5700 W Highway 61	Lutsen	MN	55612
Lutsen	North Shore Winery	Winery	202 Ski Hill Road	Lutsen	MN	55612
Lutsen	Solbakken Resort on Superior	Lodging	4874 West Highway 61	Lutsen	MN	55612
Lutsen	Cascade Lodge	Lodging	3719 West Highway 61	Lutsen	MN	55612
Minnesota	Askov Finlayson	"North" brand retail	204 N 1st St,	Minneapolis	MN	55401
Minnesota	Barefoot Aqua Sports	Watersports excursions	2659 Meridian Drive	Minneapolis	MN	55422
Minnesota	Bent River Outfitter	Outfitter	530 N Riverfront Dr B	Mankato	MN	56001
Minnesota	Bob Mitchell's Fly Shop	Fishing	550 Vandalia St #119	St. Paul	MN	55114
Minnesota	Borealis Wool Co.	Outdoor clothing	3021 10th ave s	Minneapolis	MN	55407
Minnesota	Broken Paddle Guide Company	Paddle Guiding	213 Main St W	Wabasha	MN	55981
Minnesota	Clean Lakes MN	MN Lakes branded shirts		Grey Eagle	MN	
Minnesota	Clear Waters Outfitting	Paddlesports shop	100 Pine St	Clearwater	MN	55320
Minnesota	Cooke Custom Sewing	Paddling and camping gear	7290 Stagecoach Trail	Lino Lakes	MN	55014
Minnesota	Country Ways	Snowshoe mfg.	6001 Lyndale Ave S A	Minneapolis	MN	55419
Minnesota	Finn Sisu	XC Ski shop/outdoor gear	2436 Larpenteur Ave W	Lauderdale	MN	55113
Minnesota	Full Curl Brand	up-north/backcountry-branded clothing/g	PO Box 68	Andover	MN	55304
Minnesota	Gear West	XC Ski shop/outdoor gear	1786 Wayzata Blvd	Long Lake	MN	55356
Minnesota	Great Lakes Clothing Co.	Northern branded clothing	610 SE 9th St #106	Minneapolis	MN	55414
Minnesota	Hard Water Sports Adventure Outfitting	Camping/paddling rental & guiding	511 Main S	Sandstone	MN	55072
Minnesota	Humble Apparel Co	BWCA branded apparel		Minneapolis	MN	
Minnesota	Joe's Sporting Goods	Outdoor gear and apparel	33 County Rd B E	St. Paul	MN	55117
Minnesota	Layne Kennedy Photography	BWCA photography	4209 Garfield Ave	Minneapolis	MN	55409
Minnesota	Lole Twin Cities	Outdoor apparel	337 N Washington Ave	Minneapolis	MN	55401
Minnesota	Mend Provisions	Fishing shop	2719 E 42nd St	Minneapolis	MN	55406
Minnesota	Midwest Mountaineering	Outdoor gear and apparel	309 Cedar Ave S	Minneapolis	MN	55454

Minnesota	Modern Carnivore	Hunting and gathering publication	14000 Brandbury Walk	Minnetoank	MN	55345
Minnesota	Nighthawk Canoes	Canoe manufacturer	6055 Yankeetown Rd	Boonville	IL	47601
Minnesota	North 61	up-north-branded clothing	1624 Harmon Place, Suite 300	Minneapolis	MN	55403
Minnesota	Northmade Co	up-north-branded clothing	610 SE 9th St #107	Minneapolis	MN	55414
Minnesota	Northstar Canoes	Canoe manufacturer	12363 320th Ave	Princeton	MN	55371
Minnesota	Pilgrim Paddles	Guiding		Rochester	MN	
Minnesota	Pioneer Midwest	Ski, canoe and gear shop	415 County Rd 81	Osseo	MN	55369
Minnesota	Project Canoe	Canoe-branded decor	3901 Foss Rd. NE	St. Anthony	MN	55421
Minnesota	Rapala & Family of Brands	International fishing equipment company	10395 Yellow Circle Drive	Minnetonka	MN	55343
Minnesota	Sota Clothing	Northern branded clothing	6102 Olson Memorial Hwy	Golden Valley	MN	55422
Minnesota	Sun & Slope	Outdoor apparel	701 Lake St E #175	Wayzata	MN	55391
Minnesota	The General Store of Minnetonka	up-north-branded retailer	14401 MN-7	Minnetonka	MN	55435
Minnesota	Trailtopia	Camping food	4338 4th PI NW	Rochester	MN	55901
Minnesota	Voyageur Maps	BWCA maps	PO Box 2401	Minneapolis	MN	55402
Minnesota	Wenonah Canoe, Inc.	Canoe manufacturer	1252 Bundy Blvd	Winona	MN	55987
Minnesota	Fjällräven	Outdoor clothing - Minneapolis, St. Paul,	Bloomington stores			
Minnesota	Patagonia	Outdoor clothing	1648 Grand Ave	St. Paul	MN	55105
Minnesota	REI Co-op	Outdoor gear and apparel - Bloomington,	Maple Grove, Roseville stores			
Minnesota	Riverwood Designs	northwoods cabin furniture maker	12745 Three Culverts Rd. NE	Bemidji	MN	56601
Minnesota	2ndgear.net	Outdoor gear shop	9165 Highway 53, Rm 200	Cotton	MN	55724
Minnesota	Hoigaard's	Outdoor gear shop	5425 Excelsior Blvd	St. Louis Park	MN	55426
Sawbill Trail	Sawbill Canoe Outfitters	Outfitter	4620 Sawbill Trail	Tofte	MN	55615
Sawtooth Trail	Trestle Inn Restaurant & Saloon	Food	7 Cramer Rd	Finland	MN	55603
Silver Bay	North Shore Scenic Cruises	Site seeing cruises	99 Beach Drive	Silver Bay	MN	55614
Silver Bay	AmericInn	Lodging	150 Mensing Drive	Silver Bay	MN	55614
Silver Bay	Lucky Dog Creations-Graphic Arts	Arts	36 Shopping-Center-Wells Fargo	Silver Bay	MN	55614
Silver Bay	Adam's Automotive/Auto Value	Automobile repair	99 Outer Drive	Silver Bay	MN	55614
Silver Bay	J&H Auto Repair & Towing	Automobile repair	91 Outer Drive	Silver Bay	MN	55614
Silver Bay	The Two Old Guys Small Engine Repair LLC	Automobile repair	5805 Lax Lake Rd	Silver Bay	MN	55614
Silver Bay	Zup's Kozy Korner Deli & Bakery	Food	3 Shopping Center	Silver Bay	MN	55614
Silver Bay	Dilly Dally Thrift Store	Thrift Store	Mary MacDonald Center - 99 E	Silver Bay	MN	55614
Silver Bay	Maxwell's Woodland Nursery	Florist	6185 Lax Lake Road	Silver Bay	MN	55614
Silver Bay	Zup's Dollar - Flowers & Gifts	Florist	1 Shopping Center	Silver Bay	MN	55614
Silver Bay	Bri-Esa's Convenience Store	Convenience Store	94 Outer Dr	Silver Bay	MN	55614
Silver Bay	Wilderness Family Naturals	Natural Food Retailer	MacDonald Ctr, Suite 1 - 99 E	Silver Bay	MN	55614
Silver Bay	Zup's Grocery Store	Grocery	3 Shopping Center	Silver Bay	MN	55614
Silver Bay	Mariner Mobil (NSOP)	Gas	93 Outer Drive	Silver Bay	MN	55614
Silver Bay	Second Hand Rose	Gifts	4898 Hwy 61	Silver Bay	MN	55614
Silver Bay	Vicki's Corner Store & License Bureau	Gifts	24 Shopping Center	Silver Bay	MN	55614
Silver Bay	Baptism River Inn B&B	Lodging	6125 Hwy 1	Silver Bay	MN	55614
Silver Bay	Mariner Motel	Lodging	46 Outer Dr	Silver Bay	MN	55614
Silver Bay	Split Rock Cabins	Lodging	3668 Hwy 61 E	Silver Bay	MN	55614
Silver Bay	Ecbeck State Campground	Camping	Hwy 1 & Baptism River	Silver Bay	MN	55614
Silver Bay	Laker Taker Charter & Tours	Guide/Fishing		Silver Bay	MN	55614
Silver Bay	Silver Bay Marina	Marina		Silver Bay	MN	55614
Silver Bay	Silver Bay Golf Course	Golf	19 Golf Course Rd	Silver Bay	MN	55614
Silver Bay	Northwoods Family Grille	Food	6 Shopping Center	Silver Bay	MN	55614
Silver Bay	Jimmy's Pizza & Ice Cream	Food	96 Outer Dr	Silver Bay	MN	55614
Tofte	Coho Cafe	Food	7192 W Highway 61	Tofte	MN	55615

Tofte	Bluefin Bay Resort	Lodging	7192 W Highway 61	Tofte	MN	55615
Tofte	Chateau LeVeaux on Lake Superior	Lodging	6626 W Highway 61	Tofte	MN	55615
Tofte	Surfside on Lake Superior	Lodging	10 Surfside Dr,	Tofte	MN	55615
Tofte	Watersedge Trading Company	Outdoor apparel, gear, and gifts	7124 W Highway 61	Tofte	MN	55615
Tower	Fortune Bay Resort Casino	Casino	1430 Bois Forte Rd	Tower	MN	55790
Tower	Nordic Home North	Interior Design/Rugs	303 Main St	Tower	MN	55731
Tower	Wilderness At Fortune Bay	Golf	1450 Bois Forte Rd	Tower	MN	55790
Tower	The Y Store	Convenience Store	6368 MN-169	Tower	MN	55790
Tower	The Ledge Liquor Store	Liquor Store	6380 MN-169	Tower	MN	55790
Tower	Zup's	Grocery Store	315 Main St	Tower	MN	55790
Tower	Benchwarmer Grille	Restaurant	701 MN-169	Tower	MN	55790
Tower	Sulu's Espresso Cafe	Coffee Shop	507 Main St	Tower	MN	55790
Twig	Twig General Store	Convenience Store	5302 Twig Blvd	Duluth	MN	55791
Two Harbors	3M Museum	Museum	203 Waterfront Dr.	Two Harbors	MN	55616
Two Harbors	Lighthouse Bed and Breakfast	Lodging	1 LightHouse Point	Two Harbors	MN	55616
Two Harbors	Viking Motel	Lodging	1429 7th Ave	Two Harbors	MN	55616
Two Harbors	Voyageur Motel	Lodging	1227 7th Ave	Two Harbors	MN	55616
Two Harbors	Superior Gateway Lodge	Lodging	465 Westover Rd	Two Harbors	MN	55616
Two Harbors	Breezy Point Cabins on Lake Superior	Lodging	540 Old North Shore Road	Two Harbors	MN	55616
Two Harbors	Earthwood Inn, Grill, & Bar	Restaurant and Lodging	933 Stanley Rd	Two Harbors	MN	55616
Two Harbors	Superior Shores Resort	Lodging	1521 Superior Shores Drive	Two Harbors	MN	55616
Two Harbors	Castle Haven Resort	Lodging	3067 E Castle Danger Road	Two Harbors	MN	55616
Two Harbors	Gooseberry Cabins	Lodging	3044 E Castle Danger Road	Two Harbors	MN	55616
Two Harbors	Larsmont Cottages	Lodging	596 Larsmont Way	Two Harbors	MN	55616
Two Harbors	Grand Superior Lodge	Lodging	2826 Hwy 61	Two Harbors	MN	55616
Two Harbors	Gooseberry Trailside Suites	Lodging	3317 Hwy 61	Two Harbors	MN	55616
Two Harbors	Gooseberry Park Cottages and Motel	Lodging	2778 Hwy 61	Two Harbors	MN	55616
Two Harbors	Vanilla Bean Restaurant	Food	812 7th Ave	Two Harbors	MN	55616
Two Harbors	Black Woods Bar and Grill	Food	612 7th Ave	Two Harbors	MN	55616
Two Harbors	Carmody 61	Food	1102 7th Ave	Two Harbors	MN	55616
Two Harbors	Cedar Coffee Company	Food and Coffee Shop	1130 11th St	Two Harbors	MN	55616
Two Harbors	Vietnamese Lantern Restaurant	Food	629 7th Ave #8	Two Harbors	MN	55616
Two Harbors	Arrowhead Transit	Transportation	520 South Ave	Two Harbors	MN	55616
Two Harbors	The Northshore Pizza & Coffee House	Food and Coffee Shop	802 7th Ave	Two Harbors	MN	55616
Two Harbors	Do North Pizzeria	Food	15 Co Hwy 20	Two Harbors	MN	55616
Two Harbors	Ledge Rock Grille	Food	596 Larsmont Way	Two Harbors	MN	55616
Two Harbors	Splashing Rock Restaurant	Food	2826 MN-61	Two Harbors	MN	55616
Two Harbors	Rustic Inn Cafe	Food	2773 MN-61	Two Harbors	MN	55616
Two Harbors	Java Express	Food and Coffee Shop	502 7th Ave	Two Harbors	MN	55616
Two Harbors	SpokeNGear	Bike Shop	1130 11th St	Two Harbors	MN	55616
Two Harbors	Mocha Moose Coffee Cafe	Coffee Shop	543 Scenic Dr	Two Harbors	MN	55616
Two Harbors	Louise's Place	Food and Coffee Shop	19 Waterfront Dr	Two Harbors	MN	55616
Two Harbors	McQuade's Herbs, Spices, and More	Herb and Spice Store	632 1st Ave	Two Harbors	MN	55616
Two Harbors	Judy's Cafe	Food	623 7th Ave	Two Harbors	MN	55616
Two Harbors	Castle Danger Brewery	Brewery	17 7th Ave	Two Harbors	MN	55616
Two Harbors	Lakeview National Golf Course	Golf	1349 MN-61	Two Harbors	MN	55616
Two Harbors	Betty's Pies	Food	1633 Hwy 61	Two Harbors	MN	55616
Two Harbors	Kamloop's Restaurant	Food	1521 Superior Shores Dr	Two Harbors	MN	55616
Two Harbors	Ben Redden Transport	Transportation		Two Harbors	MN	55616

Two Harbors	Northern Rail Traincar Inn
Two Harbors	Stonegate on Superior
West of BWCA	Voyagaire Lodge
West of BWCA	Nelson's Resort
West of BWCA	Andromeda Cabin
West of BWCA	Wildwood Escape
West of BWCA	Crane Lake Bar & Grill
West of BWCA	Norway Lodge
West of BWCA	Voyageurs Landing Resort
West of BWCA	Pine Point Lodge, Resort
West of BWCA	Lakeview Motel
West of BWCA	Gateway Resort Outfitters
Winton	Fat Chicken Greenhouse & Garden Center
Winton	Jeff Karasti Wood Products Plus

Lodging
Lodging
Lodging
Lodging
Lodging
Lodging
Food
Lodging
Lodging
Lodging
Lodging
Lodging
Outfitter
Feed Store/Landscaping
Interior Design/Remodeling

1730 Hwy 3
412 Scenic Drive
7576 Gold Coast Rd
7632 Co Rd 424
7485 Nelson Rd
7281 Handberg Rd
7546 Gold Coast Rd
7502 Gold Coast Rd
7511 Gold Coast Rd
7533 Gold Coast Rd
7533 Gold Coast Rd
7614 Gold Coast Rd
218 Lake St
PO Box 154

Two Harbors	MN	55616
Two Harbors	MN	55616
Crane Lake	MN	55725
Crane Lake	MN	55725
Crane Lake	MN	55725
Crane Lake	MN	55725
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Crane Lake	MN	55725
Winton	MN	55796
Winton	MN	55796

Sulfide-Ore Copper Mining
and/or
A Sustainable Boundary Waters Economy:
The Need to Consider Real Tradeoffs

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Carolyn Alkire, PhD

October 2017

Prepared for:

Northeastern Minnesotans for Wilderness



Research and strategy for the land community.

EXECUTIVE SUMMARY

The USDA Forest Service is considering how to analyze the environmental impacts of the proposed withdrawal, for up to 20 years, of 234,328 acres of federally-owned lands within the watershed of the Boundary Waters Canoe Area Wilderness (BWCAW) from the federal mining program (USDA Forest Service, 2017). Because environmental impacts include effects on the economy, the question of how many jobs might be created by new mining activity in the Arrowhead region (defined here as St. Louis, Lake, and Cook Counties, Minnesota) is important. Equally important, but something that has so far been lost in the debate, is how many jobs and how much income in other sectors, and how much economic value that may not show up in job and income statistics—what economists refer to as “non-market” value (Stout, Winthrop, & Moore, 2015)—could be destroyed by the introduction of novel mining activity.

Proponents of *sulfide-ore copper mining* argue that the choice between this new type of mining and amenity-based development is a false choice for the Arrowhead region (Praxis Strategy Group, 2017). Those making this claim point to the continued existence of the *taconite mining* industry during the now decades-long expansion of amenity-based development in the region as proof that northeastern Minnesota can, in essence, “have it all.” According to this argument, the region can gain a relative handful of higher-paying jobs in mining; it can continue to have an abundance of high-quality recreational, scenic, and environmental amenities; and it can have jobs, income, and quality of life that exist in the region because of those amenities.

If the proposed sulfide-ore copper mining raised only the same environmental concerns as taconite mining and/or the sulfide ores were located as far away from the Boundary Waters as taconite mining and not within the BWCAW watershed, this argument might warrant consideration. But sulfide-ore copper mining presents more serious risks, such as acid mine drainage, and it would introduce risks in and around the Boundary Waters—the area that represents and produces those high-quality natural values that are the foundation of the region’s new economy. It is therefore far more likely that the “false choice” argument is itself false. There are two primary reasons:

First, the “we-can-have-it-all” claim relies on a distorted picture of the economy in which the size and importance of mining is inflated relative to the size and importance of the amenity-based development that sulfide-ore copper mining may disrupt. This distorted picture comes from studies that focus only on the economy’s exports (whether mining or tourism experiences) to the exclusion of other important facets of the economy. Those studies rely on a model of economic development that is decades, if not generations, behind the times. The studies incorrectly assume that only sales to buyers from somewhere else—for example, a steel mill or a vacationer from out-of-state—bring revenue to or support jobs in the local and regional economy. Such studies count jobs in the mines or at a resort, but they ignore jobs and income that exist in Arrowhead region due to what is known as “amenity-based development.”

Amenity-based development is economic activity in a host of industries, including recreation/tourism, construction, personal and professional services, retail, and others that arrives or stays in a region for the sake of its scenic, recreational, environmental, and quality-of-life amenities. These amenities induce an in-migration (and support the retention) of human capacity (entrepreneurs, skilled workers) that is the real engine of economic development. Amenities also attract and retain consumers, including retirees and working-age people who could do their jobs anywhere, but who would prefer to live in a place with a high quality of life.

In a world where many jobs can be done from almost anywhere, economic research must begin with an understanding of what it is that makes people choose any given location. This is not to say that the presence of a raw material is immaterial, but it does mean that, as in the days of classical economists David Ricardo and Adam Smith, one needs to pay attention to all of the factors that bestow comparative advantage on a region.

The economy of the Arrowhead Region has moved away from dependence on mining and now has a more diverse and stable economy. This has been particularly true since the early 1980s when steel manufacturing in the United States experienced significant declines that reduced demand for iron ore, including from the Arrowhead region. Structural changes in American industry, improvement in transportation, shipping, and communications networks, and new ways of hiring, working, and living have meant changes, described below, in the Arrowhead region similar to those seen in many high-amenity areas around the country. Increases in recreation and tourism are a big part of those changes, but so is the ability of people to locate their businesses and themselves where they will. While the Arrowhead still has taconite mining, forest products, manufacturing, and other “goods-producing” industries, it now relies predominately on environmental amenities and the quality of life to attract and retain business owners, workers, visitors, and retirees. Those who choose the region create and/or support jobs in diverse industries, including construction, manufacturing, recreation services, lodging and dining, and personal, professional, and educational services.

Second, the “we-can-have-it-all” claim is based on a false assumption that all mining, no matter what type or where it occurs, is compatible with all recreation, tourism, and other amenity- and/or quality-of-life-driven development. Taconite mining (particularly in places farther away from the BWCAW, its gateway communities, and from watersheds that give the Boundary Waters its name and its scenic and environmental quality) is not the same as sulfide-ore copper mining in the Boundary Waters watershed, on those communities’ doorsteps, and among the homes and businesses that exist where they do because of that scenic and environmental quality.

It is certainly true that amenity-based development has accelerated in the Arrowhead region while mining employment has continued (albeit at a much lower level), but it does not mean that further mining for different ores and with different environmental effects would not dampen or reverse that development. Indeed, as our preliminary investigation and scenarios reported below suggest, the introduction of sulfide-ore copper mining could cost the region the unique resources that are the basis for its sustainable economic development.

In this report, we review the composition of the Arrowhead Region’s economy as it has evolved over the past several decades. We demonstrate that demographic, employment, and income trends are consistent with a now-established understanding of how rural economies actually grow. In a nutshell, people follow amenities, and jobs follow people. Or, as McGranahan, Wojan and Lambert (2010) conclude, there is a “trifecta” of attractive outdoor amenities, creative workers, and entrepreneurship strongly associated with employment and business growth in areas that would otherwise face difficult economic challenges.

Regional economic trends, explored in detail in the body of this report, are consistent with this dynamic. The Arrowhead region has seen

- steady growth in population (after an early-1980s decline),
- steady increases in employment and personal income in diverse industries,
- growth in proprietors’ employment and income, and

- increases in non-labor income (such as investment income and Social Security payments) from people who may be living in or coming to the region to retire.

Looking forward, we also consider how these trends could change with the proposed advent of sulfide-ore copper mining in the watershed of the Boundary Waters. Based on information from business owners, retirees, and others, we consider how such mining, by changing the availability of attractive amenities and changing the quality of life, could change the trajectory for future prosperity in the region. We consider impacts on the recreation and tourism industry, on the broader amenity-based economy, and on the land values that may be diminished due to proximity to potential mining activity.

As explained below, based on conservative assumptions, sulfide-ore copper mining in the watershed of the Boundary Waters could bring the following effects for the three-county Arrowhead study region:

- \$288 million in lost visitor spending each year that would otherwise support
 - 4,490 local jobs
 - \$76 million in residents' income
 - \$31 million in state and local taxes, and
 - \$181 million in proprietor's income and business-to-business transactions
- 5,066 to 22,791 lost jobs, and between \$402 million and \$1.6 billion in lost annual income in the rest of the economy if sulfide-ore copper mining suppresses or reverses growth in the amenity-based economy that has been the backbone of the region's recovery since the early 1980s
- \$509 million in lost property value. This is a one-time drop in asset value that will spawn annual reductions in local property tax revenue throughout the Arrowhead region.

We do not claim that these estimates are complete. Indeed, we suspect that there may be threshold effects or feedbacks that would make actual effects much larger than what we have included in the scenario. Moreover, our estimates do not include the direct costs of long-term monitoring for, and attempts to mediate the occurrence of, acid mine drainage. Nor do they include direct impacts on local governments who may face higher road maintenance, water treatment, or other costs. The estimates developed here, therefore, should be taken as a first approximation of the sort of detailed analysis the Forest Service should complete as part of its Environmental Impact Statement examining the effects of the proposed withdrawal of federal land from the federal minerals leasing program, for a period of 20 years.

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Carolyn Alkire is an environmental economist with 35 years of experience in research into the economics of land and resource management. Prior to joining Key-Log Economics, she was a resource economist with The Wilderness Society, worked for private consulting firms supporting federal agencies, and was Senior Regional Economist for San Diego's metropolitan planning organization. She earned a Ph.D. in Public Policy from George Washington University, M.S. in Economics from North Carolina State University with a Statistics minor, and B.A., *cum laude*, from the University of Richmond.

We thank Heather Meier, a volunteer with Northeastern Minnesotans for Wilderness, and John Stoner, our intern at Key-Log Economics, for invaluable research assistance.

Key-Log Economics remains solely responsible for the content of this report, the underlying research methods, and the conclusions drawn. We have used the best available data and employed appropriate and feasible estimation methods but nevertheless make no claim regarding the extent to which these estimates will match the actual magnitude of economic effects experienced if the Forest Service does not implement its proposed withdrawal of lands from the federal mining program.

THE ARROWHEAD ECONOMY

Area Overview

St. Louis, Cook, and Lake Counties make up what is called the Arrowhead Region of Minnesota (see Figure 1 below). This region boasts the natural beauty of forests and deeply interconnected streams, lakes, wetlands and groundwater. Beautiful destinations within the region include Voyageurs National Park, the Superior National Forest, and across the northern border of this region, the Boundary Waters Canoe Area Wilderness.

Reputed to be America's most visited wilderness, the BWCAW attracted 155,611 visitors in 2016 (The Wilderness Society, 2017; USDA Forest Service, 2017). The Boundary Waters contains 1.1 million acres of near-pristine water and unspoiled forests and wetlands that are as important to wildlife as they are attractive to people.

"Minnesota is known for its north woods and clean water. Those of us that live here value that and value the fact that we can vacation in our own back yard up north. Many people have cabins or lake homes in the northern part of the state. Many people dream to retire in the area. The state of Minnesota enjoys a very healthy diversified economy. I believe this is possible because of what our state has to offer to prospective businesses and talent they can bring to the state because of our quality of life."

--Retail Business Owner (Anonymous Survey)

Recreational resources include 1,200 miles of canoe and kayak routes, 1,175 lakes, 12 overnight hiking trails and more than 2,000 campsites (Ely Chamber of Commerce, 2016)

The Arrowhead Region's natural landscape attracts visitors who love to hunt, hike, camp, canoe, fish, and relax outdoors in a wilderness setting. As such, the landscape is vital to supporting the tourism industry of Northeastern Minnesota.

In addition, the Arrowhead Region of Minnesota exhibits what some researchers have termed "the rural growth trifecta"—a combination of outdoor amenities, creative workers, and entrepreneurship (McGranahan, Wojan, and Lambert, 2010). The area attracts retirees, seasonal residents, those working remotely (e.g., "digital nomads"), and entrepreneurs who could set up shop anywhere but who choose to do so in places with a high quality of life.

TRANSFORMATION OF THE ARROWHEAD ECONOMY, 1970-2015

The Arrowhead Region (St. Louis, Lake, and Cook Counties) in Northeastern Minnesota is home to a large taconite mining industry once understood to be *the* major driver in the local economy. In 1970, one in ten jobs and 15 cents per dollar of income earned were in the mining industry. Decline in the U.S.-based steel industry meant less demand for iron ore and, by the mid-1980s, the mining boom in the Arrowhead had ended. Automation has increased per-worker productivity, and mining's contribution to Minnesota's Gross State Product has stabilized, hovering around 1% over the past two decades (Cao and Tate, 2016, with Minnesota data downloaded from <https://bea.gov>). The other side of the productivity coin, however, has been a continued, steady decline in employment, and today fewer than 3 in 100 jobs and less than 5 cents per dollar in personal income is directly attributable to mining.

Beyond “Folk Economics”

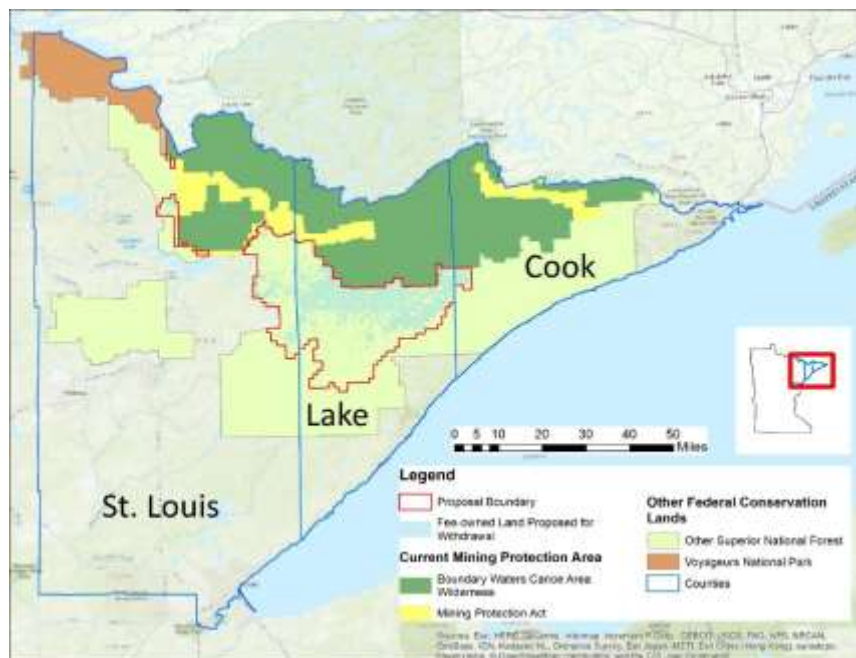
If the traditional view or “mental model” of regional economic development were still applicable, the decline in taconite mining in the Arrowhead region would doom the region to long-term decline. But such a model is, at best, out of date, and any consideration of the region’s alternative futures must be grounded in mental model, or conception, of an economy built on fundamental values in addition to the sale of material goods to other regions.

Dr. Thomas Power, in discussing the potential effects of a copper mining operation in Arizona, explains how much of our popular understanding of how economies work is rooted in “the export base view of the local economy” (2010, p 4). In this view or model, people from the local or regional area grow crops, mine for minerals, harvest timber or otherwise extract a product from the land and then export that product to another region in exchange for cash. A slightly evolved version of this model recognizes that tourism is part of the “export base” along with other goods-producing industries. The only difference is that exporting an experience (i.e., tourism) requires the buyer to come to the region, leave his or her money behind, and then take the experience home with them. In this model, that initial export transaction is the basis for all other economic activity, because the farmer, the miner, the logger, and the tourism provider all have to employ local people as laborers and buy various goods and services from other local businesses. The lumberman may hire a trucking company and buy equipment, the farmer may hire a farmhand and buy seed, and the tourism provider hires staff and buys provisions to outfit visitors’ trips into the backcountry. Empirical versions of the economic base model, generically known as “input-output models” combine the effects of spending by the employees of the exporting businesses with spending by the employees of the businesses that serve the exporting businesses to generate estimates of “multiplier effects”. These multipliers purport to show how much “output” in the form of jobs or income the region gets as a result of the initial “input” of spending on the exported goods or services. There is a limit to these rounds of impacts, because eventually some business or household is going to IMPORT a good or service from somewhere else and dollars that had been circulating among local firms “leak” out of the local economy and go on to stimulate some round of spending in another region.

There are many things wrong with this conceptual model and many more wrong with the empirical input-output models used to estimate impacts and multipliers. Not least of these, are that the empirical models have little predictive power (Krikelas, 1991) even in cases ideally suited to their

Figure 1: The Arrowhead Region

Public Lands, including the Boundary Waters Canoe Area Wilderness, and Areas Proposed for Withdrawal from the Federal Mining Program.



Sources: USDA Forest Service; U.S. Bureau of the Census; ESRI base map.

underlying structure and assumptions (Roberston, 2003). It has been 32 years since H.W. Richardson looked and concluded that 40 years' experience with economic base models [to that date] "[had] done nothing to increase confidence in them". In addition, he concluded that it would be hard to "resist the conclusion that economic base models should be buried, and without prospects for resurrection (Richardson, 1985)." Nevertheless, consultants and others persist in using these models because they conform to faulty, "folk-economic" assumptions and they provide the impressive sounding answers that those promoting various development schemes, tax breaks, or other policies may want decision makers or the public to hear.

Fundamentally, however it is not the export of goods, services, or experiences that determines the economic fortunes of a region. Rather, it is the underlying productive capacity of all of the region's resources. It is the combination of natural capital with the creativity, energy, and spirit of the people occupying those places. (Natural capital capacity for natural systems to provide food, raw materials, clean water, pleasant scenery, and recreational opportunities, among other "ecosystem services" essential to the health and well-being of people (Farley, 2012))

If the economic base model's assumption that "people will simply go to where the jobs are" was true in the past, it is true no longer. Today, people can locate where they will, and given the choice, will go where the quality of life is high, even if that means accepting a lower cash income. Niemi and Whitelaw call this getting a "second paycheck" in health, recreational access and other values, that compensates for the income they give up by not moving to a less desirable location (1999, 18). (See also Roback (1982 and 1988) for earlier statistical analysis of this phenomenon.) Moreover, businesses are comprised of people, and the people who are business owners and managers often choose to locate their business in places that offer a high quality of life, and where they can find workers who appreciate that second paycheck.

Power (2010) puts it this way:

Areas that have mixes of qualities that make it easy for those areas to attract and hold residents, will have a relatively large, diverse, and skilled workforce available at a somewhat lower price. Alternatively, such areas can get workers to move to the area without wages being bid up significantly. That makes such areas attractive to businesses. The fact that businesses are run by people who also have preferences about where they and their families live, only adds to the economic importance of a community's attractive qualities (p. 3).

He concludes that an appropriate and adequate evaluation of the impact of economic changes (Power happened to be writing about potential copper mining as well) must consider the supply side of the labor market and not just the demand for labor "created" by export-oriented development. Because it is the supply of labor attracted to a region that matters most to the region's development, this newer model of regional development is typically called a "supply-side" model.

Amenity-based development has taken the place of mining as the engine of economic development in the Arrowhead region. Amenity-based development is economic activity connected to a region's scenic, recreational, environmental (clean air, clean water), and other quality-of-life assets. Amenity-based development extends far beyond the recreation and tourism industries to any good- or service-producing industry that sells homes, cars, personal or professional services, food, etc. to people who move to, or stay in, a region because of its scenic beauty, quality of life, and in the case of the Boundary Waters, unique, world-renowned recreational opportunities. Construction, medical and financial services, all manner of retail, and other diverse industries are all contributors to (and beneficiaries of) the amenity-based economy of the Arrowhead region.

This new economy still has an export component: when people from outside the region come to Ely or Grand Marais to visit, they take away the experience and the memory of the landscape, and share it with others who may be convinced to visit. Unlike mining, such use of the landscape's scenic, recreational, and other amenities can be repeated indefinitely without fundamentally altering the landscape or diminishing its capacity to supply similar values to future visitors or future generations. In other words, the Arrowhead's amenities are a resource much like minerals, with the important exception that amenities are not used up by use.

Key Trends in the Arrowhead Economy

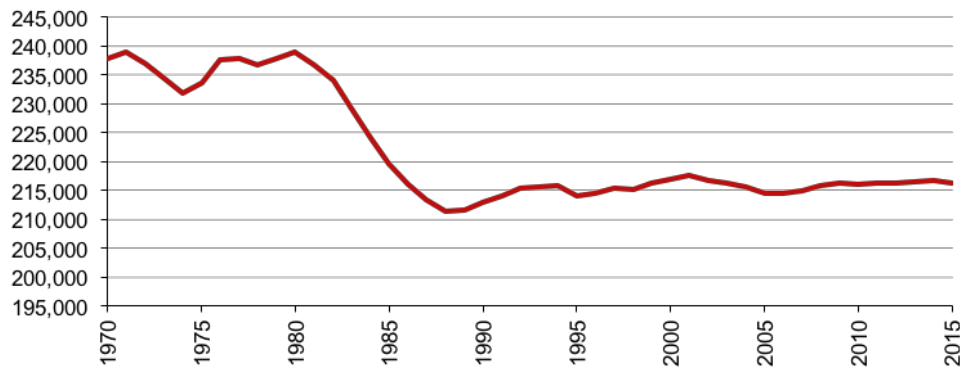
- The recession of the early 1980s coincided with a decline in mining from 10% of regional employment in 1980 to 2.5% in 2015.
- Services, including those directly connected to the region's high quality outdoor amenities (recreation and tourism) and those indicative of robust amenity-based development (construction, professional and other services) were already growing in the early 1980s and have continued to outpace all other sectors since.
- Today, more than 7 in 10 jobs are "services related."
- The fastest employment growth (since 2010) in the services category is coming from
 - information (up 13.4%)
 - professional services (up 12.3%)
 - real estate (up 12.1%)
 - educational services (up 10.0%)
 - arts, entertainment, and recreation (up 8.9%)
- The population of the three-county Arrowhead Region containing the Boundary Waters has been stable since 1990.
- Population, employment and income trends indicate the attractiveness of the Arrowhead Region to retirees and entrepreneurs.
 - Median age has increased and the largest increases in population have been among people 45 and older.
 - In 1980, sole proprietors represented slightly more jobs than mining. Today there are seven times as many proprietors as mining jobs.
 - Since 2000, growth in proprietors' employment has outpaced growth in wage-and-salary employment by a factor of 4.5 (10.3% in 2015, up from 2.3% in 2000).
 - While labor income has grown (by 8.8% since 2000), non-labor income from investments and transfer payments like social security have increased by nearly four times as much (by 33.3%).
 - Non-labor income accounts for 42% of all personal income in the region (up from 26% in 1970), with investment income and age-related transfers making up three quarters of non-labor income.
- Since the late 1980s, unemployment trends in the Arrowhead Region have tracked closely with those in the State of Minnesota as a whole.

Demographic Trends

Total Population: Decline and Regrowth

From 1970 to 2015, the total population declined from 237,809 to 216,256 people, with most of the change occurring between 1980 and 1988—a period of steep decline in mining employment. Since 1988, the population has rebounded, by 2.3% or 4,812 persons. However, from 1990 to 2014 the population of the three-county Arrowhead Region has been stable with modest growth of 2%. (See Figure 1.) (Note that these population estimates include only year-round residents, not seasonal residents.)

Figure 2: Population, Arrowhead Region, 1970 – 2015



Source: Headwaters Economics: Economic Profile System-
<https://headwaterseconomics.org/>: SocioEconomic Measures: Underlying Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Table CA30.

Age of the Population

The Arrowhead region's population is older, and, apart from St. Louis County, is getting older faster than the population of Minnesota as a whole. From 2000 to 2015, the median age in Minnesota and in St. Louis County increased by 2 years; in Lake and Cook Counties, the increase was 7 years. Within the Arrowhead region, there are fewer in the under 18 and 35-44-year-old age brackets, with gains coming in the 18-34, 45-64, and 65 and over brackets. While not definitive, the gains in the older two brackets, coupled with the region's rapid rise in age-related transfer payments (i.e., Social Security and Medicare payments--see below), suggest an increase in the number of people choosing the region for their retirement.

Figure 3: Change in Median Age, Arrowhead Counties and Minnesota, 2000 - 2015

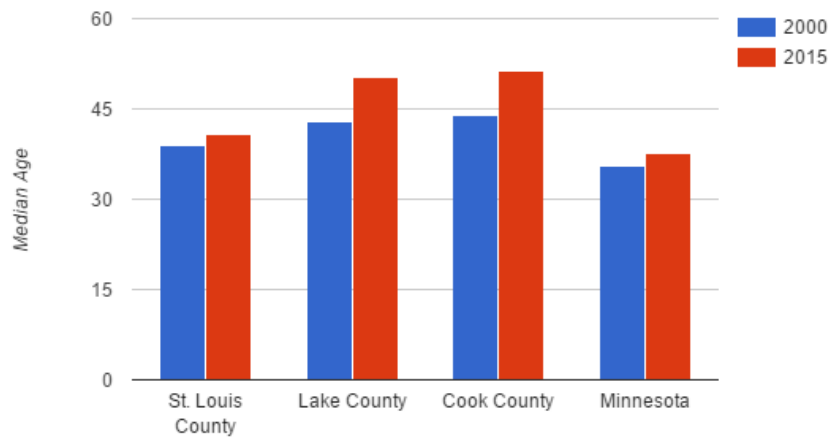
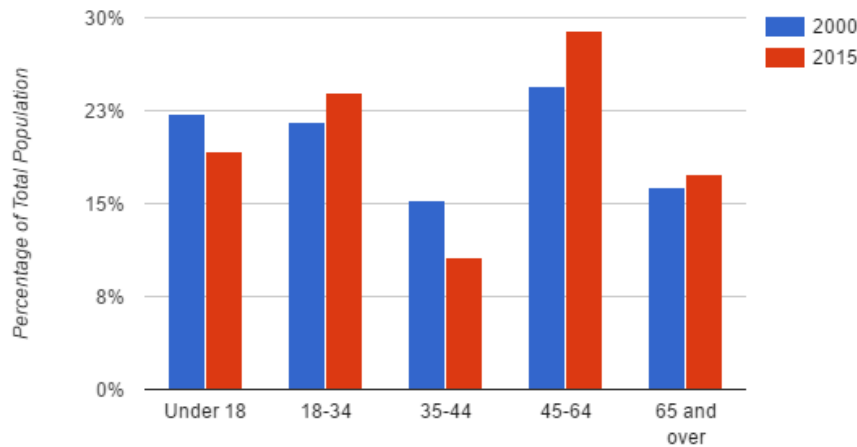


Figure 4: Age Distribution, Arrowhead Region, 2000 and 2015



Sources: US Census Bureau. (2017). American Fact Finder. Retrieved from <https://factfinder.census.gov/>; Headwaters Economics. (2017). Economic Profile System. Retrieved from <http://headwaterseconomics.org/tools/eps-hdt>

Housing

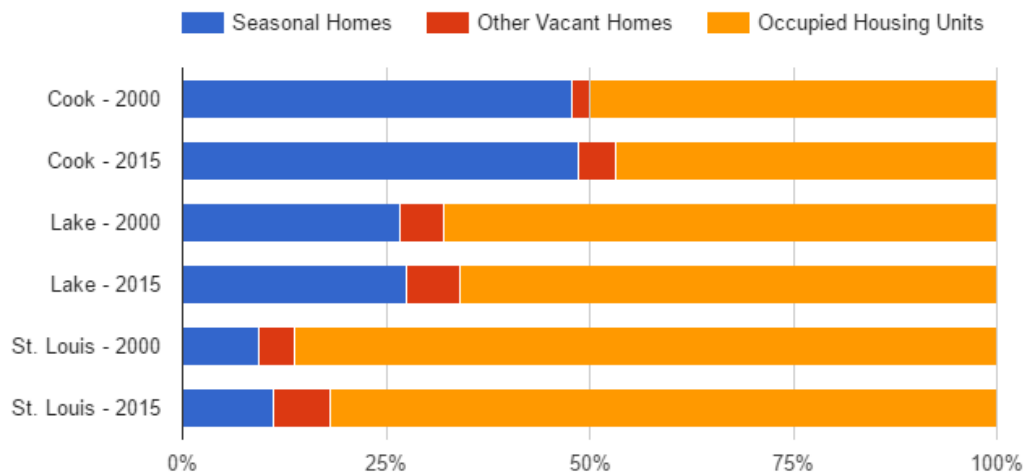
The Arrowhead region added almost 10,000 housing units (+8.6%) from 2000 through 2015. During the same period, the region's population was nearly flat (476 fewer people, or a decline of 0.22%). This seeming disconnect reveals two trends: more people are moving into their own housing units (as sign of increasing overall prosperity); and more people are building vacation homes in the region. In contrast to the 8.6% increase in overall housing units, the number of housing units for "Seasonal, Recreational, or Occasional Use" increased by 26% in the region. In Lake and Cook Counties vacation homes now comprise nearly one third and one half, respectively, of all housing units. St. Louis County, which has many more housing units to begin with, is adding vacation homes at the fastest rate (up 29% since 2000).

These housing trends illustrate the attractiveness of the region for regular visitors. It also helps explain some of the other trends we'll describe below, including increases in jobs and income in construction, real estate, and a host of other industries that people would use in the course of purchasing land,

building a home, and then using it repeatedly over the course of years. Groceries, utilities, home maintenance, health care while in the region, restaurant meals, and others are all part of the package when people invest in a region based on its quality of life.

The housing trends may also be a harbinger of still more future growth, if the current owners of homes for seasonal or occasional use become full-time residents. Some of these owners could be looking ahead to converting the homes for retirement use, and some may decide to move their job or business to the region. Either would represent important, long-term economic development opportunities for the Arrowhead region.

Figure 5: Housing Units by Type, Arrowhead Counties, 2000 & 2015



Sources: US Census Bureau. (2017). American Fact Finder. Retrieved from <https://factfinder.census.gov/>

Employment and Income

Unemployment Rate

In the mining bust of the early 1980s, unemployment rates spiked to nearly 20%. Since 1988, however, Arrowhead unemployment rates have remained much lower, and they have tracked closely with the statewide unemployment rate (Figure 6). This is consistent with what one would expect of an increasingly diverse economy. In another sign of increased resilience in the Arrowhead region since the late 1980s, recessions have not pushed unemployment as high and the recovery from them has been faster than before the mining bust (Figure 7).

Figure 6: Unemployment Rate, Arrowhead Region, 1976-2015

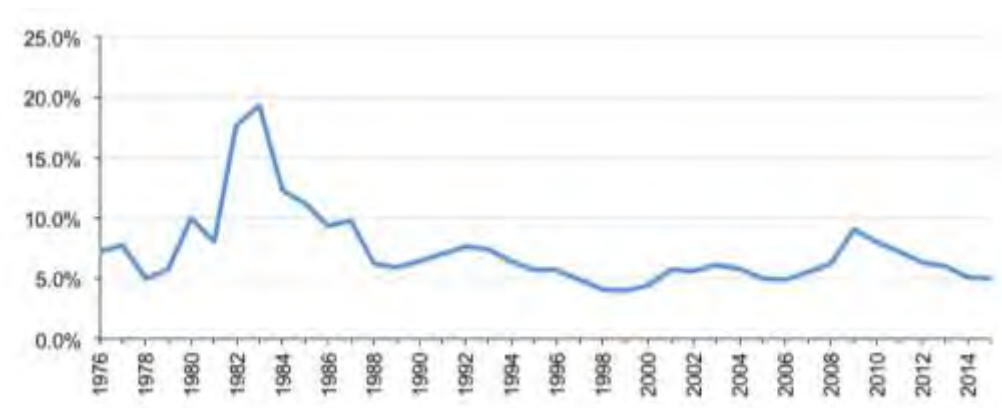
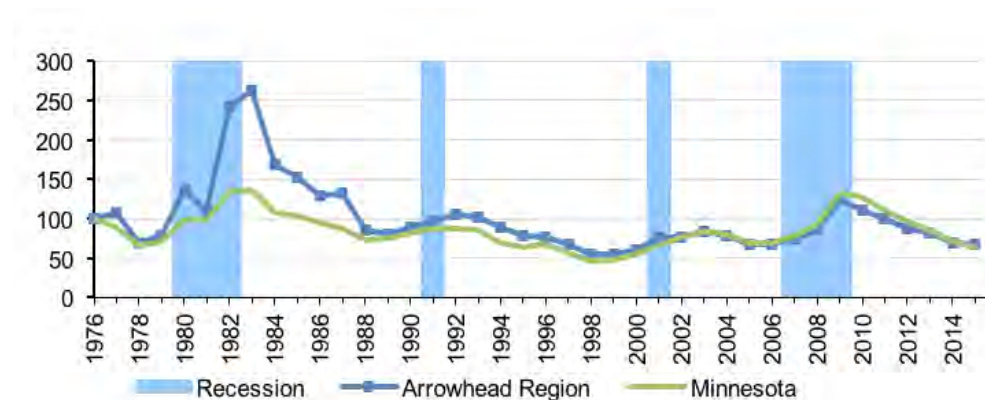


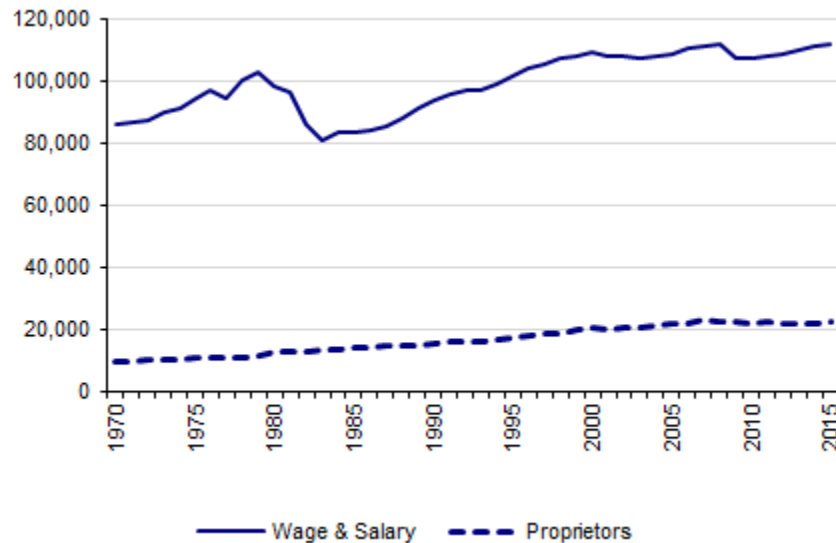
Figure 7: Unemployment Rate, Arrowhead Region and Minnesota, 1976-2015 (indexed with 1976=100)



Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>: SocioEconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Labor. 2016. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

From 1970 to 2015, total employment in the Arrowhead region grew from 95,516 to 134,402, a 41% overall increase that erased losses sustained due to the mining-led bust of the early 1980s. From 1983 to 2015 jobs grew by 39,933, a 42% increase. While wage and salary jobs (that is, working for someone else) are most common, proprietorships are growing faster--by more than 10% since 2000, compared to the 2.3% increase in wage and salary employment over the same period (Figure 8).

By 2015, one worker in six was self-employed. This concentration of proprietors indicates the region's "entrepreneurial breadth", which is one of several key rural assets that supports economic prosperity and resilience in today's global economy (Low, 2004).

Figure 8: Employment by Type, Arrowhead Region, 1970 - 2015

Source: Headwaters Economics: Economic Profile System-
<https://headwaterseconomics.org/>; Socioeconomic Measures Report: Data Sources:
 U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional
 Economic Accounts, Washington, D.C. Table CA30.

Income by Source

The income earned by wage-and-salary workers and by proprietors is “labor income”, and that accounts for 58.3% of total personal income of Arrowhead region residents. The other 41.7% is “non-labor” income and is comprised of income from past investments (dividends, interest, and rent), plus transfer payments, like Social Security and Medicare. Non-labor income has increased by a third (33.1%) since 2000, while labor income has increased by just 8.8%. Because non-labor income is attached to a person and not to a job or company, this is an important part of a region’s economic engine, and may be particularly sensitive to changes in quality of life, including the availability of recreational and environmental amenities. People can retire where they want, and, other things being equal, they are more likely to choose places with a safe and pleasant natural environment.

Earnings per job and income per person tell a similar story. While average earnings are increasing for wage and salary employees in the Arrowhead region (Figure 10), average income per person is rising much faster. Like the demographic trends, this reflects an aging population with relatively more investment and retirement income.

Figure 9: Labor and Non-Labor Income, Arrowhead Region, 1970 - 2015

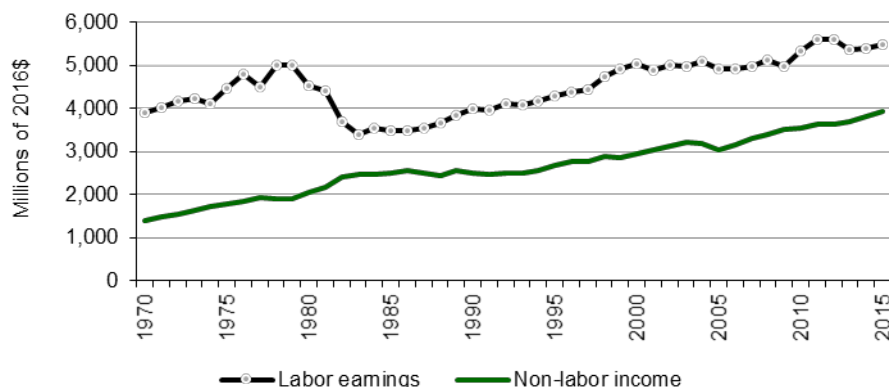
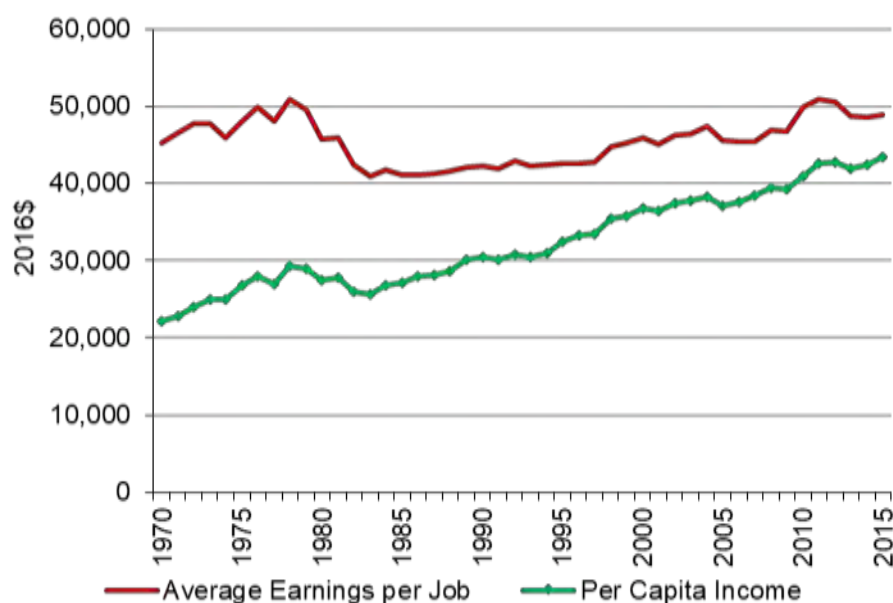


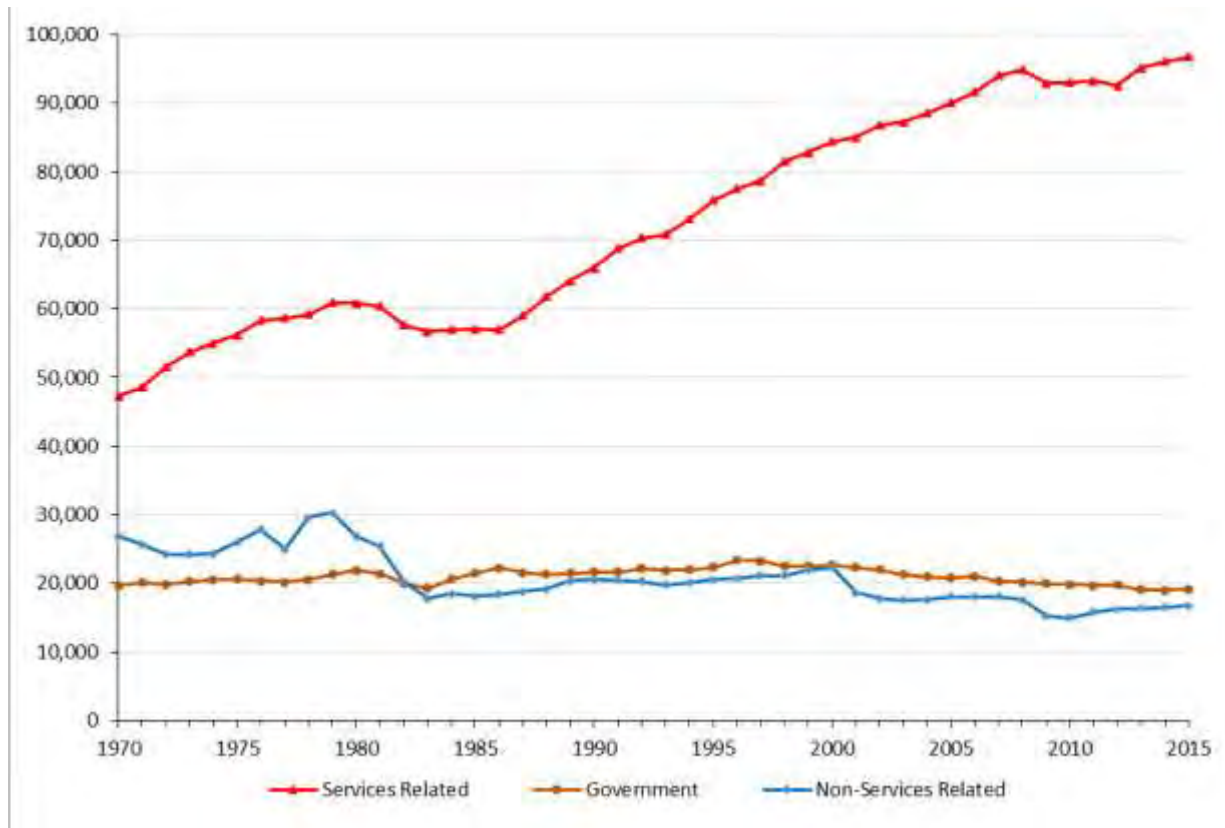
Figure 10: Earnings per Job & Per Capita Personal Income, Arrowhead Region, 1970 – 2015



Source: Headwaters Economics: Economic Profile System-
<https://headwaterseconomics.org/>: Socioeconomic Measures Report: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Table CA30.

Employment and Income by Industry

Since the decline of mining in the early 1980s, total employment in the public sector and in the goods-producing industries (farming, mining, construction, and manufacturing as a whole) has remained flat, while employment in services has grown steadily. Today, almost three out of four jobs are in services, while only one in eight is in the goods-producing industries. There are differences among the industries that comprise these broad categories, however. For example, the region has seen steady increases in construction employment, which reflects the increases in housing stock already discussed. The effects of amenity-based development, in other words, are not restricted to the service-producing sectors.

Figure 11: Employment by Major Industry Category, 1970 – 2015

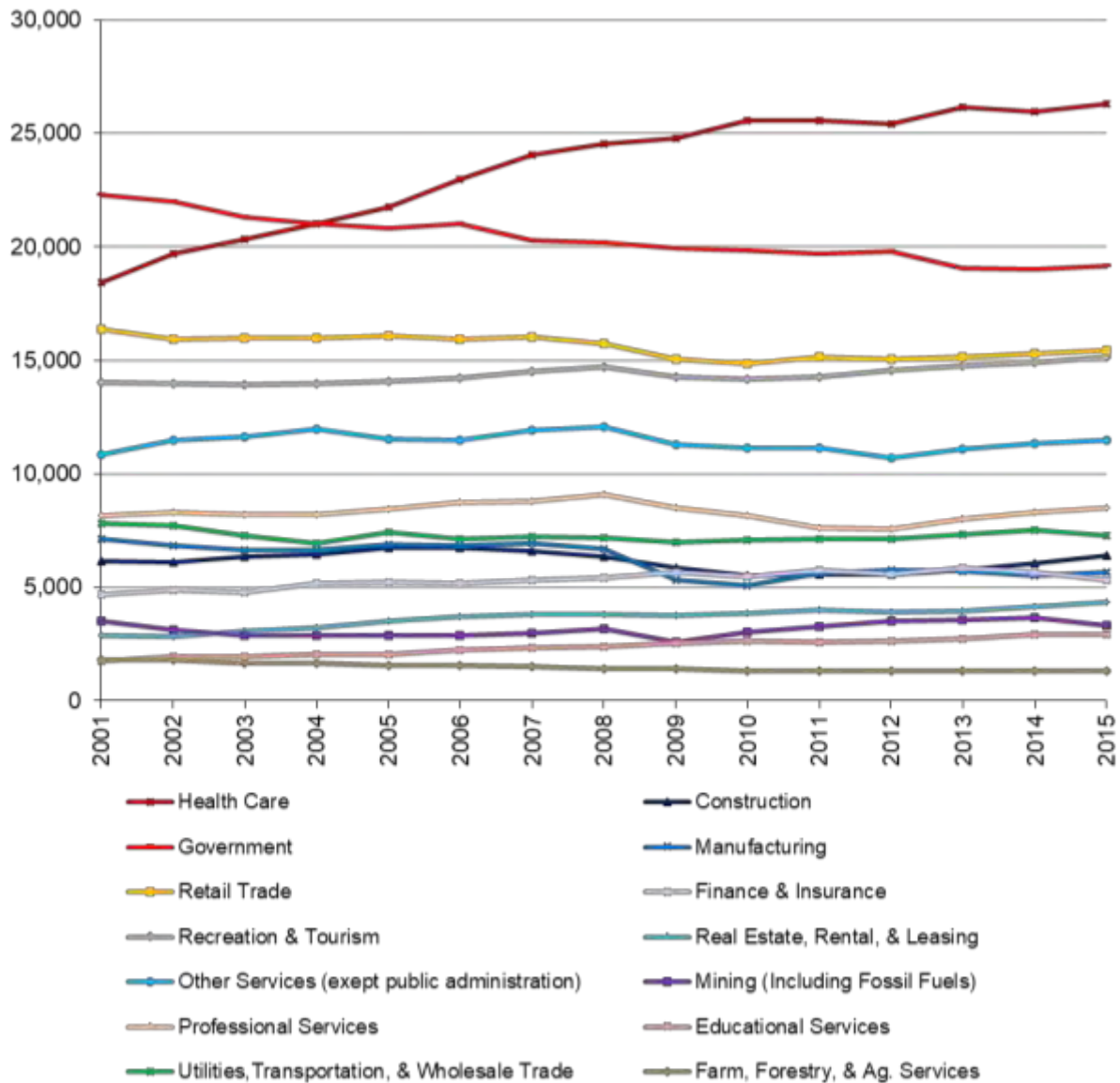
Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>; Socioeconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA25 & CA25N. The series is split at 2000-2001 due to the changes in the classification of industries that does not allow direct comparisons of all data from before and after the change.

The steady increase in the number of jobs in service-related industries, coupled with the relative stability of the Arrowhead economy since 1988 indicates the extent to which the regional economy has moved beyond mining-dependence and does not need to favor the production of material goods for export to survive. (See “Beyond Folk Economics”, page 2.) Instead, the Arrowhead region has been able to recover and prosper on the basis of diverse economic activity, much of which is directly or indirectly related to the quality of the environment more broadly.¹

Recreation and tourism represents 11.3% of all jobs in the region, which are perhaps most closely tied to how visitors perceive and enjoy the region’s natural assets. Visitors also support local businesses in the retail trade (11.5%), real estate rental and leasing (3.2%), educational services (which may include camps if the camp owners self-identify their business as an education rather than a lodging business) (2.2%), and other industries. Given the number of firms making outdoor apparel and equipment, and other products used by visitors, recreation and tourism also supports and is tied to local manufacturing employment and income (4.2%).

¹ It is important to note, however, that there is significant variation among smaller geographic areas within the Arrowhead Region, and some communities are more or less dependent on goods-exporting industries versus service-producing industries.

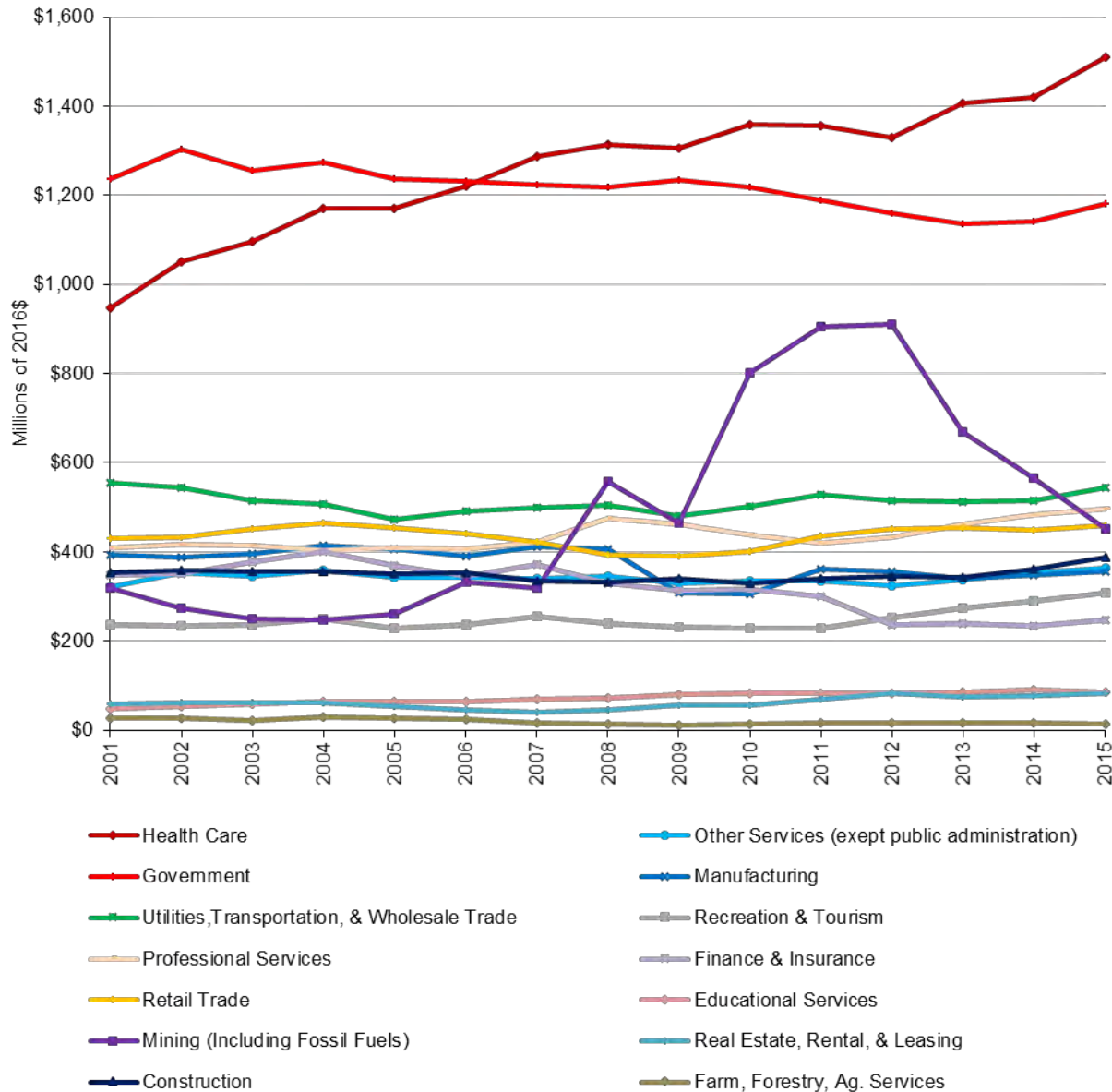
Figure 12: Employment by Industry Group, Arrowhead Region 2001 - 2015



Note: "Recreation & Tourism" includes Arts, Entertainment, and Recreation as well as Accommodation and Food Services. "Other Services" includes Other, Administrative, and Waste Services. "Professional Services" includes Professional Services, Management of companies and enterprises, and Information. "Utilities, Transportation, & Wholesale Trade" includes these categories and Warehousing. "Farm, Forestry, & Ag. Services" includes Farm, Forestry, Fishing, and Ag. Services.

Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>; SocioEconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA25N.

Figure 13: Earnings of Workers, by Industry, Arrowhead Region, 2001-2015, Millions of 2016\$



Note: "Recreation & Tourism" includes Arts, Entertainment, and Recreation as well as Accommodation and Food Services. "Other Services" includes Other, Administrative, and Waste Services. "Professional Services" includes Professional Services, Management of companies and enterprises, and Information. "Utilities, Transportation, & Wholesale Trade" includes these categories and Warehousing. "Farm, Forestry, & Ag. Services" includes Farm, Forestry, Fishing, and Ag. Services.

Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>; SocioEconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA05N.

Recreation-and-tourism-driven employment and income are just a portion of the region's amenity-based development, however. Retirees and entrepreneurs who move to the region for its quality of life are perhaps even more important, because they create and support jobs in the local and broader regional economy by using health care (19.6% of jobs), professional services (6.3%), financial services

(“Finance and Insurance”) (4%), as well as services of the construction and real estate industries (8% cumulatively).

These statistics alone do not tell us many of the people behind these employment figures are located in the Arrowhead region for the sake of its environmental and other quality-of-life amenities. It is clear from other sources of information, however, that such amenities are important to decisions to move to or stay in this particular region as well as in other similar high-amenity areas (Ronnader, Wentz, and Hove, 2014; Florida, 2000; Niemi and Whitelaw, 1999; Northeastern Minnesotans for Wilderness 2016). Therefore, to mistake recreation-and-tourism as the sum total of amenity-based development would miss much of the contribution of natural capital to the Arrowhead Economy. By the same token, to compare employment, wages, and other economic impacts from mining to those in recreation and tourism alone, as in the report by the Praxis Strategy Group (2017), is to present a distorted picture of the full extent of the “opportunity cost”² of sulfide-ore copper mining.

Trends in earnings or income by industry, depicted in Figure 13, look much like the employment trend, with the largest share of income and some of the most rapid growth occurring in services. One relevant difference between graphs is that the pronounced boom and bust in mining *income* between 2008 and 2015 does not seem to have translated into much change in mining *employment* during that time. This suggests that while those with mining jobs do comparatively well in the boom times, the boom does not do much to increase the number of mining jobs.

Visitor Expenditures and the Tourism Industry

It should be clear by now that there are many facets to the amenity-based economy of the Arrowhead region. Tourism, however, is usually the first industry that comes to mind when one thinks about the impacts of potential land use change and loss of environmental quality. In this section, therefore, we focus on the various economic effects of the attractiveness of the Boundary Waters to visitors from other places.

Unlike “mining”, “construction”, “professional and technical services”, or other industries, there is not a single industrial classification into which all facets of the visitor services industry, or tourism as we will call it from here on, fits. Rather, the tourism industry is comprised of pieces of industries that, to varying degrees, serve visitors and residents alike. Air transportation, hotels and other lodging places, and some services might be used primarily by visitors. Restaurants, guiding and outfitting services, outdoor retailers, gas stations, and grocery stores, however, serve both residents and visitors. Estimates of jobs or income by industry, therefore, need to be augmented with other data in order to get a complete picture of the tourism industry, leavened with survey data reflecting how and where tourists actually spend their money.

Those who lose with sulfide-ore copper mining would be Arrowhead, Twin Cities, and other Minnesota residents who, perhaps having chosen their location to be near the amenities of the Boundary Waters, now have to spend more time and money to get to somewhere else.

² “Opportunity cost” is economists’ term for what a person or the economy as a whole inherently loses in making a choice between competing options. In this case, the opportunity cost of sulfide-ore copper mining would register as jobs and income in the amenity-based economy, along with other values.

Davidson-Peterson Associates conducted such a survey of visitors for Explore Minnesota Tourism in 2007 and 2008 and developed county-by-county estimates of traveler expenditures in Minnesota and the jobs, state and local tax revenues, and other impacts those expenditures support (Davidson-Peterson Associates, 2008). Of Minnesota's 87 counties, St. Louis, Cook, and Lake Counties ranked third, thirteenth, and sixteenth from the top in terms of in-county traveler expenditures. The total for the Arrowhead region in 2008 was \$1.1 billion (adjusted for inflation to 2015 dollars). These expenditures supported almost 15,800 full-time equivalent jobs, nearly \$300 million in workers' income, and \$119 million in state and local tax revenue (all in 2015 dollars). The balance, roughly \$700 million, went to other businesses and to owners of the direct tourism businesses.

To gain a more current picture of these contributions to the Arrowhead region's economy, we turn to another Explore Minnesota report conducted by Tourism Economics (2016) which estimated year-by-year expenditures and other metrics for the entire state. According to the report, statewide visitor expenditures grew at an average annual rate of 4.97% from 2009 to 2015. Starting from the 2008 base for the Arrowhead region and applying the year-by-year growth rates for the entire state, we estimate that expenditures in the Arrowhead region would have been \$1.42 billion in 2015, which would have supported 22,174 full-time-equivalent jobs, \$376 million in resident's income, and \$152 million in state and local tax revenue.

It is important to note that these estimates reflect only those expenditures by out-of-state visitors. Minnesotans residing outside the Arrowhead who visit the region to recreate in the Boundary Waters, as well as Arrowhead region residents who recreate close to home, add to the expenditure totals and further support the region's tourism industry. As discussed under "Beyond Folk Economics" (on page 2), such expenditures by in-region or in-state residents may not be considered a true economic impact because the dollars spent are already there. We contend, however, that those expenditures should be counted as part of the economic contribution of the Boundary Waters and of the natural amenities of the Arrowhead region. The reason is that Arrowhead residents and all Minnesotans can choose where to spend their recreation and tourism dollars. If sulfide-ore copper mining were to make the Boundary Waters less suitable or attractive a place to spend one's time and money, then some portion of those expenditures by Minnesotans would occur somewhere else. The Arrowhead region would lose, and another region, perhaps one that had not sacrificed its wilderness character or environmental quality, would gain. Among the losers, of course, would be those Arrowhead, Twin Cities, and other Minnesota residents who, having chosen their location to be near the amenities of the Boundary Waters, would now have to spend more time and money to get to somewhere else.

Seasonal Residents

As the information on seasonal housing on page 6 indicates, the Arrowhead region has many part-time or seasonal residents. A recent study of four townships³ by the University of Minnesota, Morris' Center for Small Towns (2014) reveals that seasonal residents spend an average of \$8,008 per household per year (in 2015 dollars) in the local economy. If this average is typical of the 16,357 vacation/seasonal homes across the Arrowhead region, seasonal residents would contribute some \$131 million per year to the region's economy. This spending supports businesses and employment in all industries, including construction, automotive service, medical, retail, and entertainment.

³ The townships included in the study are Morse, Fall Lake, Stony River, and Eagles Nest.

POTENTIAL EFFECTS OF SULFIDE-ORE COPPER MINING ON THE ARROWHEAD REGION'S ECONOMY

The current dominant narrative from proponents of sulfide-ore copper mining seems to be focused on predictions of new jobs and economic prosperity due to new mining activity without any consideration of the magnitude of the economic costs. Indeed, proponents of sulfide-ore copper mining, by claiming the region can “have it all”, espouse a view that there would be no costs at all.

Proponents of sulfide-ore copper mining would do well to recall the famous aphorism from Nobel Laureate Milton Friedman: “There is no such thing as a free lunch.” Decision makers, in other words, should not forget that there is an “opportunity cost” to the introduction of sulfide-ore copper mining into the watershed of the Boundary Waters. This cost includes lost visitor spending and the jobs and income associated with it, lost economic development throughout the economy as sulfide-ore copper mining makes the region less attractive as a place to live and do business, and lost property value as residents flood the market with first and second homes located in places where it is no longer desirable to visit or reside.

We therefore provide the following preliminary estimate for some of these key economic costs of sulfide-ore copper mining. We want to emphasize, however, that our estimates reflect only impacts on a limited number of **market** values (property value, jobs, and income) and are, therefore, very conservative estimates of the full **economic** value at stake. Economics recognizes that the dollars that change hands in the marketplace (or don't change hands, as would be the case with sulfide-ore copper-mining-induced changes in the Arrowhead economy) are just a partial indicator or reflection of the total economic value of natural resources and the environment. For every dollar paid in market value, such as for travel or lodging to recreate in the BWCAW, to buy hard goods and provisions for the trip, or to buy a seasonal or permanent home in the region, there is additional “non-market” value in the form of the traveler's/homeowner's satisfaction from the experience. For most people and for most market transactions, there is a “consumer surplus” defined as what people *would* pay for a good, service, or experience over and above what they *do or have to pay* (that is, the market price) for it.

Our estimates do not include direct costs of monitoring and attempting to mitigate potential and actual damage to ecosystems that may occur over the course of opening, operating, and in a few short years, shutting down mining operations. The need to monitor for acid drainage and other impacts would continue for decades and centuries after operations have ceased and any benefits from sulfide-ore-mining are a distant memory. In the shorter term, erosion and sedimentation, health effects of dust and light pollution, and higher maintenance costs for roads and other infrastructure would entail expenditures by individuals and local governments as well as non-market impacts on human well-being.

Our estimates below do reflect a portion of such impacts. For example, if noise, dust, and light pollution or other insults to the ecosystem service value of land near mining sites reduces the value of a seasonal or year-round home, there would be a reduction in the market price (fewer dollars exchanged) if and when the home sells. Prior to sale, however, the current owners would experience a loss of well-being or satisfaction with their home that could be greater than the eventual loss in market value.

Finally, we have not attempted to estimate losses of what are known collectively as “passive-use value”. This is the value to people of keeping places like the Boundary Waters as clean, aesthetically

appealing, and ecologically intact as possible for the sake of potential future use by oneself (“option value”) or by one’s descendants (“bequest value”). Passive-use value also includes “existence value”, which is the value to individuals of keeping places like the BWCAW intact to even if those individuals have no expectation of ever using or enjoying the place directly.

While effects on ecosystem services and drops in passive use value may be reflected in economic measures of the effects we explore below, we do not contend that we have captured the full costs, either market or non-market, of those effects. The major caveat to these estimates, therefore, is that what we “see” or estimate here may be but the tip of a very large iceberg of economic costs that are not as readily apparent, at least not yet.

What Drives Costs of Sulfide-Ore Copper Mining?

Before getting to dollar estimates of the costs of sulfide-ore mining, we must consider what may drive the decisions to come to (or not) the region to visit, to live, or to start a business or, for those who had made such decisions in the past, whether to come back to or stay in the Arrowhead region or elsewhere in Minnesota. As noted above, the Forest Service should undertake a thorough examination of the extent to which sulfide-ore copper mining would affect such decisions. As a first step in that direction, we have considered and developed several indicators of what motivates such decisions and how strong the impacts of new mining activity in the watershed of the BWCAW might be.

Many local residents have stated that the effects of sulfide-ore copper mining operations on the community and natural environment--noise, dust, truck traffic, pollution of existing high-quality ground and surface water (which supplies drinking water to many local residents), risk of damage to fisheries and aquatic habitat--would likely result in fewer visitors to the region, discourage new businesses from locating, and deter new residents. “If there were mines in the Boundary Waters, it would change the reputation of the Boundary Waters as a whole, and damage businesses” asserts Bill Hansen, an owner of Sawbill Outfitters located between Ely and Gunflint (B. Hansen, personal communication, 2016). He continued, “once a mine has been built, it is really hard to develop new businesses near it.” Steve Piragis, owner of Piragis Northwoods Company in Ely, noted that just the perception of a sulfide-ore copper mining industrial zone on the edge of town would be enough to scare off people who might visit, or build a vacation home or otherwise settle in Ely (S. Piragis, personal communication, 2016). And the owner of Hungry Jack Outfitters (on the eastern side of the BWCAW), Dave Seaton, said he feels that there would be enough impact from the mine to damage outfitting (D. Seaton, personal communication, 2016).

In addition, residents believe the existence of sulfide-ore copper mining in the region would cause some of the current residents and businesses to leave the region (see Figures 14a and 14b, below). As the area becomes (perceived to be) less desirable, the value of remaining businesses, as well as the value of both year-round and vacation properties and related property tax receipts, all are expected to decline. Dave Seaton, for one, expressed concern about land and business values if the mine comes in, because he intends to sell Hungry Jack Outfitting at some point (D. Seaton, personal communication, 2016). Sulfide-ore copper mining would, he believes, take away from the value of the business to any prospective owner and therefore reduce the prices he might be offered.

Loving or Leaving the Boundary Waters Region

Figure 14a. Loving: Why do you choose to live or own land in the four townships area?

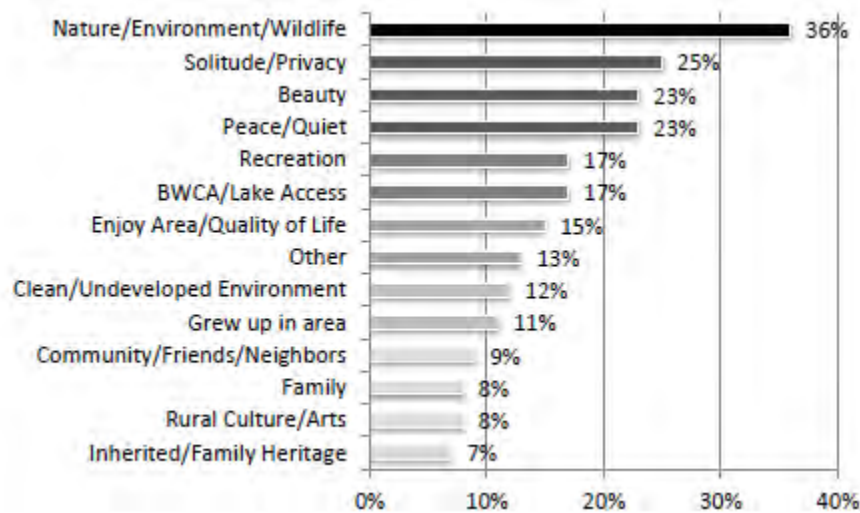
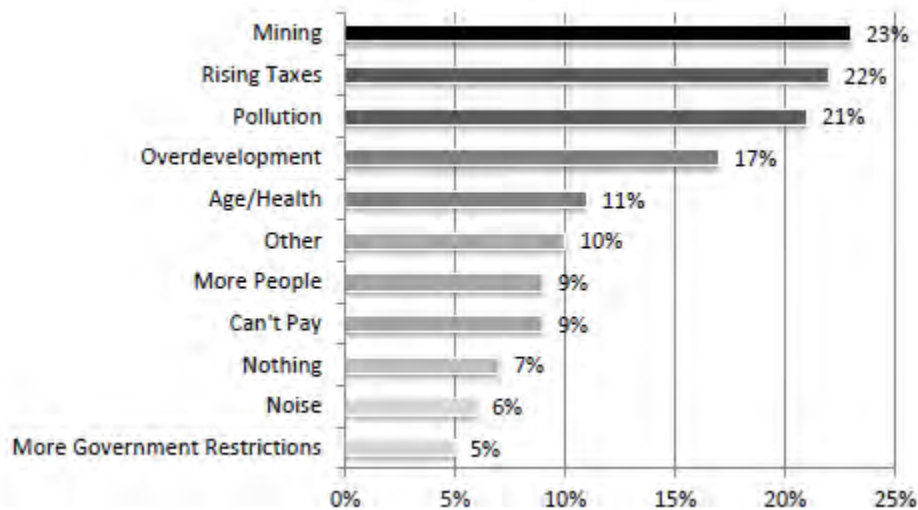


Figure 14b. Leaving: What factors would make you leave the four townships?



Source: Ronnader, R., Wentz, J., and Hove, M. (2014). *The Four Townships Area Economic, Housing Development Survey* (p. 51). Center for Small Towns and Data Services Center, University of Minnesota at Morris.

As part of *The Four Townships Area Economic, Housing and Development Survey*, researchers at the University of Minnesota, Morris asked property owners (both year-round and seasonal residents) about their reasons for owning property and/or living⁴ where they do and what might cause them to leave (Ronnader, Wentz, and Hove, 2014). The top reasons people gave for their having chosen to live

⁴ Some of the study's survey respondents owned property in the region, but do not reside there personally.

or own land in the region include “Nature”, “Beauty”, “Recreation”, “Undeveloped Environment”, and “Quality of Life” (see Figure 14a). Not surprisingly then, threats to or the loss of those amenities are among the top reasons people would leave the region. The most common reason, cited by 23% of respondents, was “Mining” (see Figure 14b). The researchers note that “a few” respondents indicated that their concern was that there are not enough mining jobs, but that mining was mentioned “mostly [by] respondents expressing [concern over] potential negative consequences from mining” (Ronnader, Wente, and Hove, 2014, p.48). The next most common reasons, each cited by more than one in five respondents, why owners and residents would leave are “Rising Taxes”, “Pollution”, and “Overdevelopment”.

Survey of Arrowhead and Minnesota Business Owners

While the “four townships” survey described above touches on the question of whether and how sulfide-ore copper mining would affect residents’ and property owners’ decisions about whether to stay in the immediate region, there has not yet been a systematic survey conducted to discern the likely effects of sulfide-ore copper mining on the outlook of businesses in Minnesota.

To be sure, businesses have spoken out both for and or against this new type of mining, and anecdotal evidence from letters to the editor, statements made at public meetings, and in other venues and documents (Northeastern Minnesotans for Wilderness, 2016) do suggest that for some businesses the advent of sulfide-ore copper mining in the Boundary Waters watershed would be catastrophic. But such data may not be readily generalizable to the whole of the economy or even to the portions that one would consider to be most directly affected by the proposed new mining industry. We therefore recommend that the Forest Service should conduct, as part of its withdrawal study, a thorough, statistically robust poll of business owners, residents, visitors, and others who have a stake in or who may hold values related to the quality of life and the quality of the environment in the watershed of the Boundary Waters.

In the meantime, we have attempted to obtain and use more systematic information as part of our estimates of potential costs presented below. Specifically, we used information from three sources:

1. Personal interviews with a group of small- and medium-sized retail, recreation, and tourism business owners from Ely and Grand Marais.
2. Review of 27 sworn affidavits filed in *Franconia Minerals (US) LLC; and Twin Metals Minnesota LLC, v. United States of America: U.S. Department of the Interior; et al.* (U.S. District Court, District of Minnesota).
3. Brief, anonymous, but nonrandom survey of business owners throughout the Arrowhead region and the whole of Minnesota. The survey was sent to 140 members of the “Boundary Waters Business Coalition,” and we received 31 responses for a response rate of 22%.

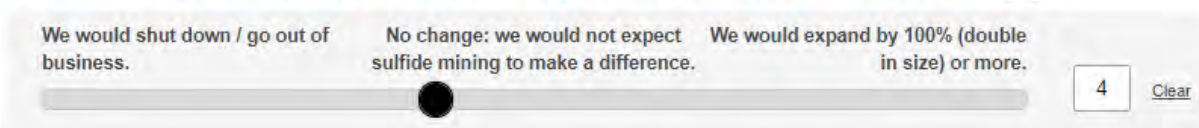
The business survey covered some basic information about each business (industry classification, size, etc.) as well as two key questions about each business owner’s (or, in some cases, a manager’s) realistic expectations for the future of their business in two scenarios: one with sulfide-ore copper mining in the watershed of the Boundary Waters, and one without. For these two questions, respondents moved a slider left or right from a “status quo” position. (See Figure 15 and Appendix A). The left and right ends of the scales represent extremes of “we expect to shut down” on the left, to “we expect to double or more” on the right. The position of the slider was automatically translated into a numerical score of zero to ten, and from this we infer a percentage change from the status quo in each scenario.

Figure 15: Survey Questions re: Business Outlook with and without Sulfide-Ore Mining in the watershed of the Boundary Waters

7. Scenario 1: If sulfide-ore mining is NOT APPROVED and the economy of the Arrowhead region (St. Louis, Lake and Cook Counties) continues to develop as it has over the past 30 years, what are your expectations for how **YOUR OWN** business/organization/agency might change **over the next 5-10 years?** 



8. Scenario 2: If sulfide-ore copper mining WERE TO BE APPROVED in the watershed of the Boundary Waters, how would you expect **YOUR OWN** business/organization/agency to change **over the next 5-10 years?** 



Note: The slider position and resulting numerical score (in the box to the right of each slider) show the average for the 31 responses received. We interpret the 7 in Scenario 1 (question 7), which is two steps above “No change” toward “...expand by 100%” to be interpretable as a 40% increase. Similarly, for Scenario 2 (question 8), the 4, which is one step (out of 5) toward “We would shut down...” to be interpretable as a 20% decrease.

Please see Appendix A for the complete survey.

From the survey responses we find that, on average, the businesses expected to grow by 40% over the next 5-10 years in a without-sulfide-ore copper mining scenario. In the with-sulfide-ore-copper-mining scenario, an average reduction in business of 20% over the same period is expected. We use this 20% reduction as the basis for estimates below of the effect of the proposed sulfide-ore copper mining industry on visitor spending, visitation, jobs, and income. Such a change does not seem unreasonable, given that traveler spending in Minnesota has increased by more than 20% in the past five years preceding 2016 (Tourism Economics, 2016)

This survey and the resulting estimates do have two countervailing caveats to keep in mind.

- First, a survey of business owners who have signed up as part of a coalition raising concerns about the mining proposal are more likely to be well-informed about the issue. Indeed, the respondents, on average, rated their awareness and knowledge of the issue as an eight on a zero to ten scale. To the extent that joining the coalition and being more informed on the issue correlates to opposition to the mining proposal, we would concede that the survey results are “biased” in the technical/statistical sense (i.e., we are not casting aspersions on the respondents), and we urge the U.S. Forest Service to conduct a random, statistically unbiased survey to get additional information about business owners’ and others’ expectations.
- Second, survey respondents do come from a range of industries (construction, manufacturing, retail, professional services, as well as recreation/tourism industries including lodging,

restaurants, guiding and outfitting). The respondents also do business from locations throughout the state. (The survey was anonymous, but we have information on industry category from a specific question, and we know something of the businesses' locations based on what some respondents volunteered in open-ended survey questions (see Appendix A). (As one might expect, businesses geographically closer to the Boundary Waters indicated that mining would have a stronger negative effect on their outlook than businesses down state.)

The fact that our cost estimates apply the statewide average to Arrowhead Region outcomes mitigates, at least partially, any sampling bias that may have colored the results. Moreover, we asked the business owners about their realistic expectations regarding the future of their businesses, not for their personal opinions. Interestingly, the lowest score on the question about expectations in the "with-sulfide-ore copper mining" scenario was a two (corresponding to a 60% reduction in the business). None of the respondents, in other words, indicated that they would go out of business completely. (Such expectations do show up in anecdotal information.) One business out of the 31 respondents, a small "retail/food & beverage" business, expects to double or more with or without the mine, even though they noted that sulfide-ore copper mining would hurt their sales and induce a change in focus toward other regions. That was an outlier, however: every other business indicated that it would either stay the same (8 businesses) or become smaller (23 businesses) in the "with-mining" scenario.

Estimated Costs: Three Ways Sulfide-Ore Copper Mining Would Affect the Arrowhead Region's Economy

There are at least three interrelated ways in which sulfide-ore copper mining would likely affect the economy of the Arrowhead region and, by extension, the entire state of Minnesota.

1. *Fewer visitors and less visitor spending:* The actual and perceived loss of environmental quality, including diminished quality of recreational experiences, would reduce the number of visitors coming to the region each year. That would translate into less spending, fewer jobs in all of the industries supported by visitor spending, and lower state and local tax revenues.
2. *Fewer in-migrants and more out-migrants:* The same effects on environmental quality would make the region less attractive to retirees, footloose entrepreneurs, mobile workers, or anyone else looking to reside or do business in a location with a high quality of life based on environmental factors and easy access to diverse, high quality outdoor activities (Florida 2000). As the "supply side" model of regional economic development suggests (see "Beyond Folk Economics", page 2), losing that quality of life will mean fewer in-migrants, more out-migrants, and as a result, less economic activity in all sectors.
3. *Loss of residential and commercial property values:* The value of being close to areas with outstanding natural amenities and opportunities for outdoor recreation is typically capitalized into nearby land values. As sulfide-ore copper mining reduces the amenities whose value is bound up with the overall value of residential and business properties, property value will fall, taking wealth away from current owners, and reducing local property tax revenue for years to come.

We consider each of these effects in turn.

Lost Visitor Expenditures

During a 12-month study period spanning 2007 to 2008, visitors (defined as persons staying one night or more in a location than 50 miles from their home) spent more than \$1 billion in the Arrowhead region (see Table 1, below) (Davidson-Peterson Associates, 2008). The study found that St. Louis, Cook, and Lake Counties ranked 3rd, 13th, and 16th, respectively, among Minnesota's 87 counties in terms of visitor spending. The study also broke down the direct impacts of that spending into its impacts in the regional economy. For each \$1 million in visitor spending, there were

- 16 direct jobs supported,
- \$264,666 in residents' income,
- \$106,770 in State (\$83,418) and local (\$23,352) tax revenue, and
- \$628,564 in proprietors' income and business-to-business spending

Note that these are direct impacts only and do not include "multiplier effects" that are calculated using input-output models. In this case, multiplier effects would comprise "indirect effects", which is spending by the businesses with whom the direct businesses (that is, those where the visitors spent their money) do business. Multipliers would also include "induced" effects that occur when people spend their earnings from work at businesses directly serving visitors or from work at the "indirect" businesses.

Davidson-Peterson Associates (2008) estimated total effects and found that multipliers in the Arrowhead region were 1.34 for jobs and 1.54 for residents' income and taxes. Thus, for every 3 jobs directly supported by visitor spending (in a hotel, at an outfitter, at a gas station, etc.) a fourth job would be supported in another business (for example, the outfitter's accountant, or the gas station's parts supplier). Similarly, for every two dollars spent by visitors, a third dollar would be spent in the Arrowhead economy, as the hotel manager, the outfitter's accountant, etc., spend their paychecks in the community.

Table 1. Estimated Direct Economic Impacts of Traveler Expenditures, 2008 & 2015, and Annual Losses with Sulfide-Ore Copper mining.

	Spending & Impacts, 2008	Impact per \$1 million Spending	Projected Spending & Impacts, 2015 (in 2016\$)	Losses with Mining (2016\$ & Jobs)
Traveler Expenditures	\$ 1,024,726,048	n/a	\$ 1,438,413,258	\$ 287,682,652
Jobs (full-time equivalent)	15,787	16	22,448	4,490
Resident Income	\$ 271,210,252	\$ 264,666	\$ 380,699,234	\$ 76,139,847
State Revenue	\$ 85,480,425	\$ 83,418	\$ 119,989,315	\$ 23,997,863
Local Revenue	\$ 23,929,452	\$ 23,352	\$ 33,589,895	\$ 6,717,979
Proprietors Income + Business-to-Businesses	\$ 644,105,920	\$ 628,564	\$ 904,134,814	\$ 180,826,963

Source: Davidson-Peterson Associates (2008), adjusted using trend data from Tourism Economics (2016).

To bring the estimates of direct visitor spending closer to the present, we turn to a recent study by Tourism Economics (2016) that tracked statewide visitor spending from 2009 through 2015. The average annual growth rate in that spending was 5.0% (range: 3.1% to 7.8%). We applied that growth rate to the Arrowhead expenditure estimate for 2008 and, applying each year's statewide growth rate,⁵ we estimate that visitor spending in the Arrowhead region reached \$1.44 billion by 2015 (in 2016 dollars) (Table 1). That 2015 spending would have supported:

- 22,448 direct jobs
- \$380.7 million in residents' income
- \$153.6 million in state (\$120.0 million) and local (\$33.6 million) taxes
- \$904.1 million in proprietors' income and business-to-business sales.

Finally, with our survey of business owners as a guide, we consider what the impact of a 20% reduction in visitor spending would mean for the Arrowhead region. Losing that \$287.7 million in spending would cost the region 4,490 jobs (about 4.9% of total private employment in the region), \$76.1 million in workers' income, \$30.7 million in state and local taxes, and \$180.8 million in proprietor's income and business-to-business sales (Table 1). That loss would occur each year that the presence and operation of sulfide-ore copper mining keeps 20% of visitors away.

Because Davidson-Peterson collected and reported data from visitors based on where they stayed (travelers were surveyed on-site during their visit), it is likely that their initial spending estimates reflect spending throughout Minnesota even though that spending is ascribed to the county where the traveler was staying when surveyed. Thus, a traveler who lodges in Ely before jumping off for a canoe trip in the Boundary Waters Canoe Area Wilderness would have been asked about all their spending to get there, what they planned to spend on provision, guiding services, what was paid for a meal at a restaurant on the way to Ely, and the cost of gas for a rental car. The entire expense of the trip would have been tagged as being due to the time in St. Louis County. By the same token, if our traveler had been surveyed during a one-night stay in a Minneapolis hotel before flying home, all those expenses would have been ascribed to Hennepin County.

This feature of the underlying data means that some travelers' expenditures are misplaced, but we assume that for any given county, the misplacement of expenditures goes both ways: some dollars are ascribed to the county that should not be, and other dollars that were spent in the county were ascribed to another county. We assume that in aggregate, these errors cancel each other out. We therefore have not attempted to estimate the portion of expenditures occurring in the Twin Cities or elsewhere in Minnesota that are, in reality, due to the attraction of the Boundary Waters.

Losses to the Broader Economy

Amenity-rich communities around the country know that a high quality of life, including a clean environment and access to high-quality outdoor recreational and scenic resources, are the natural capital that supports much of their economies. Visitation and visitor spending are certainly part of that, but the effect extends to all sectors of the economy. This is especially true for "footloose industries" or operations that do not need to be located near either input supplies (e.g., commodity raw materials),

⁵ For 2008-2009, for which calculation of a statewide annual growth rate was not possible, we used the average of the growth rates for 2009 through 2015.

or output markets. With today's global economy, and advanced communication and transportation networks, the list of industries that are footloose grows by the year.

For example, Niemi and Whitelaw (1999) state: "natural-resource amenities exert an influence on the location, structure, and rate of economic growth.... This influence occurs through the so-called people-first-then-jobs mechanism, in which households move to (or stay in) an area because they want to live there, thereby triggering the development of businesses seeking to take advantage of the households' labor supply and consumptive demand" (p. 54). They note that decisions affecting the supply of amenities "have ripple effects throughout local and regional economies" (p. 54). Similarly, Johnson and Rasker (1995) found that quality of life is important to business owners deciding where to locate a new facility or enterprise and whether to stay in a location already chosen. This is not surprising. Business owners value safety, scenery, recreational opportunities, and quality of life factors as much as residents, vacationers, and retirees.

As we have already seen (Ronnader, Wente, and Hove, 2014), environmental quality, recreational opportunities and other quality of life factors are the most important reasons Arrowhead residents give for living in and owning property in the region.

To the extent that sulfide-ore copper mining would diminish the physical qualities of the natural environment in the Arrowhead region, or even to the extent mining would alter the perception of those qualities--that is if mining damaged the region's "brand" built on the quality of the environment--one would expect that fewer people will want to relocate to the region to retire, to take a job, or to start up a new business. The "four townships" study and our business survey gives some information about the potential magnitude of that effect, and we use that information to sketch a set of simple scenarios for what the impact on jobs and income might be. We do note up front, however, that further research to determine more precisely how mining might affect location decisions by current and potential residents would be desirable as part of the review of mining in the Boundary Waters watershed.

Ronnader, Wente, and Hove (2014) found that 23% of property owners said that concerns over mining would cause them to leave, or at least want to leave, the region. Similarly, our survey of business owners indicates that sulfide-ore copper mining could depress their businesses' prospects by 20%, on average. One scenario, therefore, would be that there is a 20% drop in economic activity in the region.

As a general indicator of economic activity, we begin with total employment and total personal income. Both include proprietors' (the self-employed) additions to the economy. Total personal income also reflects the contribution of retirees in that it includes income from investments and transfer payments like Social Security and Medicare that retirees would spend in the region.

To avoid double counting, we then net out the contributions to jobs and income from visitor spending. We also net out those jobs and income in industries least likely to be footloose, namely farming, forestry, and mining itself.

We also consider two less drastic scenarios. In a second scenario, we consider the effect of a 10% drop in jobs and income, and in the third, we consider no actual drop, but merely a cessation of the growth the region has seen since the beginning of recovery from the mining bust of the early 1980s. Since 1983, the Arrowhead region has seen average annual job growth of 4.4% and average annual growth in total personal income of 5.0%.

The range of impacts from these scenarios range from a loss of 5,066 jobs and \$402.4 million in personal income (per year) if growth simply flatlines, to a loss of 22,791 jobs and \$1.6 billion in annual income if 20% of the economy were to, essentially, move away. See Table 2 for details.

Table 2: Overall Economic Decline in Three Scenarios for the Impact of Sulfide-Ore Copper Mining

	Jobs	Income (000s of 2016\$)
Total Jobs or Personal Income	134,402	\$ 9,400,027
Less Travel-Related	15,787	\$ 903,570
Less Commodity-Related	4,660	\$ 464,755
Potentially Amenity-related	113,955	\$ 8,031,702
Mining Impact Scenarios		
20% reduction	-22,791	-\$ 1,606,340
10% reduction	-11,396	-\$ 803,170
No Growth*	-5,066	-\$ 402,369
* Loss of 4.5% job growth, and loss of 5.0% income growth Sources: Headwaters Economics: Economic Profile System- https://headwaterseconomics.org/ ; SocioEconomic Measures: Underlying Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA30, CA05N, and CA25N; Ronnader, Wentz, and Hove (2014); and tourism data cited above.		

Lost Property Value

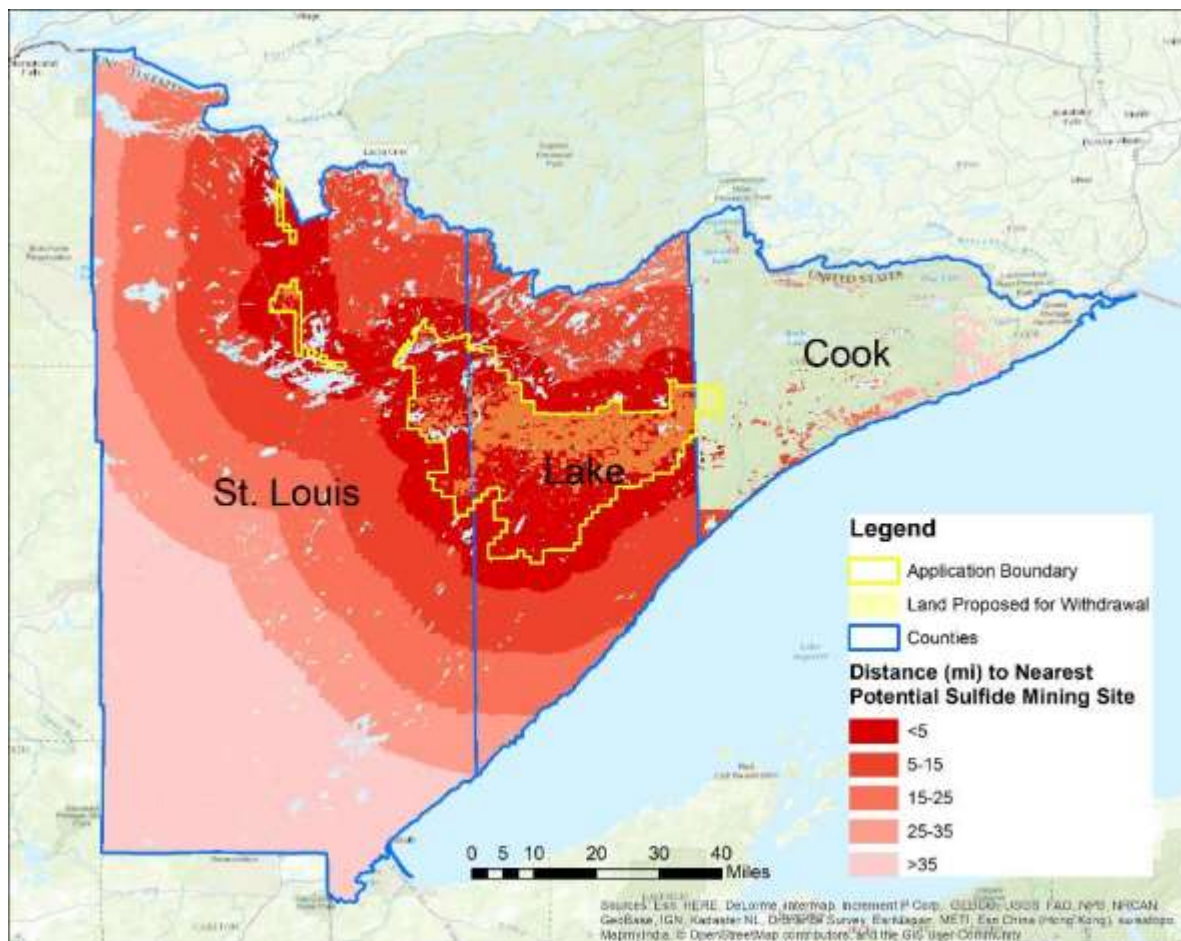
There is a ring of truth to the old saw that “location, location, and location” are the three things that matter most to the value of real estate. Namely, the location of a property relative to various amenities and disamenities can have a significant impact on buyers’ willingness to pay for the property. Natural amenities, like clear lakes (Schuetz, Boyle, and Bouchard, 2001), pastoral scenery (Fleischer and Tsur 2009), and wilderness and other protected areas (Phillips 2000; Beaton 1991) add value to properties over and above other attributes (improvements, road frontage, school quality, tax rates, etc.) that also influence land prices.

The same is true of disamenities: there are negative impacts on land value from various types of local nuisances that impose noise, light, air, and water pollution, life safety risks, and lesser human health effects risks on nearby residents and even entire communities that “gain” a new industry with such impacts (Sun, 2013; Bolton and Sick, 1999; Boxall et al., 2005; Williamson, Thurston, and Heberling, 2008). Erickcek (2006), Sun (2013), and Kim and Harris (1996) studied gravel, gold, and copper mines, respectively, and found that, in general, the closer a property is to the mine site, the lower is its property value. This negative effect typically decays with distance--that is, moving another mile closer to the mine produces a bigger drop in property value if you are already closer to the mine. In Sun’s study, which covered a time span that included both the opening and the closing of the mine, also found a large negative impact on every property in the county that occurred when the mine opened.

For this study, we apply the parameters from Kim and Harris (1996), who examined property values near a copper mine in Green Valley Arizona. To take the decay in the effect of the mine into account, they used a nonlinear transformation of distance to the mine in place of the simple distance. (The transformation is $X=1.05-(0.9947)^D$, where “D” is the distance in miles from the subject properties to the mine.) As is typical in these studies and for statistical reasons, the authors used a “log-log” version of the model in which the natural logarithm of the price of property is regressed against the natural log of the transformed distance and other variables. The coefficient on the distance function (0.2872 in their case) then represents the change, in percentage terms, of a property “moving” one percent farther away from the mine, when other things are held equal.

We do not have full information about all attributes of the properties in the Arrowhead region, but by computing distances from each property to potential sulfide-ore copper mining sites and applying the coefficient on the transformed distance, we can derive an estimate of the impact of new mining activity on properties in the Arrowhead. We conducted the analysis based on the distance from each property to the nearest Forest Service fee-owned parcel within the “Application Boundary”. In other words, we computed the distance from each private parcel to the nearest point that could, if the 20-year withdrawal is not approved, be subject to sulfide-ore copper mining. (See Figure 16).

Figure 16: Parcel Distance to Areas Potentially Open to Sulfide-Ore Copper Mining



Sources: St. Louis, Lake and Cook Counties’ respective GIS and Tax Offices, USDA Forest Service, ESRI.

We obtained parcel maps and information on the value of each parcel directly from each of the three Arrowhead counties. Due to the per-parcel fee charged for Cook County data, we obtained data only for privately owned parcels. Because publicly owned parcels do not have listed values and are not subject to sale, they should suffer no loss in market value due to mining. This gap in the data does not affect the analysis, but it is something to keep in mind when viewing the map in Figure 16. Publicly owned parcels in Lake and St. Louis Counties also have no market value, but the data sets for those counties did include all parcel boundaries.

Using the “NN Join” plugin in Quantum GIS, we calculated the distance from each parcel to the nearest polygon representing an area potentially open to sulfide-ore copper mining. The greatest potential separation is 77.9 miles to a parcel in northwest St. Louis County.

After computing these distances, and we then applied the statistical results from Kim and Harris (1996) to estimate the percentage change in property value (which is how one interprets those results when the log-log functional form is used). Parcels closest to mining sites would lose 5.74% of their value, and those farthest away would lose as little as 0.66%. By applying these percentages to each of the more than 243,000 parcels, per-parcel losses and aggregate property value losses are obtained.

Based on these procedures, we estimate that some \$508.9 million in property value would be lost if sulfide-ore copper mining were to occur on all of the areas proposed for withdrawal from the federal mining program. (See Table 3.)

Table 3. Estimated Property Value Impacts of Sulfide-Ore Copper Mining, 2016.

	Number of parcels	Total Property Value (2016\$)	Property Value Lost (2016\$)
Cook County	8,460	\$ 1,651,043,600	\$ 30,722,257
Lake County	45,303	\$ 3,378,180,900	\$ 115,161,294
St. Louis County	182,143	\$ 20,760,741,439	\$ 363,031,214
Total	235,906	\$ 25,789,965,939	\$ 508,914,765

As with other costs discussed in this report, we believe the actual impacts of sulfide-ore copper mining on land value would be much higher than those presented in Table 3. There are two primary reasons actual effects would be higher.

First, the study from which we used parameter estimates was focused on air quality impacts of copper mining that, while acute for properties closest to the mine, could decay more rapidly as distance from the mine increases. For other facets of the value of land in the Arrowhead region, such a decay may not be as pronounced, or it may not occur at all. For example, one may own (or consider buying) property in the Arrowhead region so that one can be relatively close to high quality recreational resources or to places with high levels of wilderness character.

The ability to get to high quality recreational resources and relatively pristine natural areas is reflected in buyers’ willingness to pay for properties near such resources and is capitalized into the price of properties throughout the Arrowhead region and, arguably, throughout the entire state of Minnesota. When noise, light, dust, and water pollution due to sulfide-ore copper mining diminishes the quality of the experience of areas near mining sites—or even if it diminishes only the *perception* of the quality of the experience—people will likely be willing to pay less for first or second homes purchased with an eye

toward be near the Boundary Waters. In other words, impacts on property values may remain strong over much greater distances than our conservative assumptions and these initial estimates suggest.

The other reason these property value effects are low is that they are merely “partial equilibrium” effects. They capture (at least some of) the direct nuisance effect of mining on property values, but they do not capture the second-round effects of a loss of vitality in the economy due to reductions in visitor spending and lost overall economic vitality. If population, jobs, and income decrease due to the advent of sulfide-ore copper mining, as described in the preceding sections, there will be fewer people with fewer dollars and with less optimism for a future, sustainable economy. Demand for housing will suffer along with the rest of the economy, and housing prices can be expected to fall. That may be good news for someone moving to the Arrowhead to take one of the comparative handful of new mining jobs, but for property owners already invested in the region, it will mean a loss of asset value and personal wealth.

SUMMARY AND RECOMMENDATIONS TO THE FOREST SERVICE

The Arrowhead Economy benefits from unique scenic, recreational, and environmental amenities. The clean water, peace and quiet, canoeing and hiking trails of the Boundary Waters Canoe Area Wilderness and the surrounding Superior National Forest, Voyageurs National Park, and the North Shore of Lake Superior are well-known international attractions for visitors and for new residents. In order to protect these outstanding resources “from the potential adverse environmental impacts arising from exploration and development [of mineral resources on federal lands]”, the Forest Service has proposed withdrawing 234,328 acres of federally owned land in the Rainy River watershed from the federal mining program (82 FR 4283).

The Forest Service is now scoping its Environmental Impact Analysis, which under the National Environmental Policy Act, must consider the economic effects of the proposed action alongside ecological, aesthetic, historical, social, and health effects (40 CFR 1508.8). The salient economic effects of this action would include, as a benefit to society, the avoidance of costs associated with actual and potential sulfide-ore copper mining that, absent the proposed action, could proceed in the watershed of the Boundary Waters. As the estimates described here demonstrate, even a fraction of those costs significant. The small subset of potential economic effects of sulfide-ore copper mining considered in this report include

- A decline in spending as potential visitors choose alternative destinations with high quality scenic and recreational amenities undiminished by nearby mining activity. We estimate an annual loss of \$288 million in spending that would otherwise support 4,490 local jobs, \$76 million in residents’ income, \$31 million in state and local taxes, and \$181 million in proprietor’s income and business-to-business transactions
- 5,066 to 22,791 lost jobs, and between \$402 million and \$1.6 billion in lost annual income in the rest of the economy if sulfide-ore copper mining suppresses or reverses growth in the amenity-based economy that has been the backbone of the region’s recovery since the early 1980s
- \$509 million in lost property value. This is a one-time drop in asset value that will spawn annual reductions in local property tax revenue throughout the Arrowhead region.

As the caveats given along with our methods and estimates suggest, these numeric estimates should be considered conservative first approximations of the true and complete costs of sulfide-ore copper mining in the watershed of the Boundary Waters and, by the same token, of the positive economic effects of the proposed action). We would therefore recommend the Forest Service devote sufficient time and resources to fully explore all of the economic effects of the proposed action. Specifically, the agency should include the following in its Environmental Impact Assessment:

1. Conduct a systematic survey of business owners and managers to estimate the effect of potential sulfide-ore copper mining on the outlook for Minnesota, and especially Arrowhead Region, businesses in all sectors.
2. Complete a thorough, statistically valid survey of residents, visitors, vacation and second homeowners, and other stakeholders to determine the sensitivity of individual's and other stakeholders' decisions about whether to vacation, retire, locate, or stay in the Arrowhead region under alternative scenarios involving the presence and extent of sulfide-ore copper mining in the proposed withdrawal area.
3. Commission or perform a hedonic price study of residential, commercial, and other property values in areas where similar mining operations have occurred. The scope of effects in such a study should go beyond direct air, water, and visual effect, to include effects on "wilderness character". Insights and parameters from such a study should then be used to estimate land value effects near the proposed withdrawal area.
4. Examine the extent to which forecasted mining employment in both lower- and higher-wage positions will be available to, and filled by, current Arrowhead residents. That is, how will the potential benefits of sulfide-ore copper mining be distributed among existing residents and workers brought in from elsewhere.
5. Evaluate the avoided impact on all ecosystem services that would occur if the proposed withdrawal is not implemented. Ecosystem services affected would include:
 - a. timber (a renewable raw material) from forestland is lost to mine-related infrastructure, including roads, buildings, tailings piles and others;
 - b. food, including the nutritional value of fish and game species and edible wild plants no longer able to use or thrive in terrestrial and aquatic habitat affected by mining;
 - c. water for drinking;
 - d. recreational opportunities, including as valued by impacts (expenditures, jobs, income, etc., as considered in this report) as well as by benefits (the value to the recreational user over and above the out-of-pocket cost of the recreational experience). Loss of benefit if the proposed withdrawal is not implemented would afflict would-be visitors who stay away due to the new type of mining in the Boundary Waters watershed, as well as those visitors who do come but find their experienced diminished by sulfide-ore copper mining; and
 - e. other ecosystem benefits described, for example by Balmford et al. (2010).
6. Estimate impacts on passive-use value. The Boundary Waters belong to and are loved by people throughout our Nation and the world who would want to know that its resources remain unimpaired and who would want to ensure that they or their descendants have the option of future use of the Boundary Waters without the impacts of sulfide-ore copper mining.

Above all, the Forest Service's economic analyses to be included in the Environmental Impact Statement should be grounded in a 21st-century understanding of economics and the reality that there is more to the foundation of the Arrowhead Region's economy than what can be dug up and shipped away.

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APPENDIX A: BUSINESS OUTLOOK SURVEY

Using Survey Monkey, we solicited input from 140 members of the “Boundary Waters Business Coalition”. We received 31 responses (a 22% response rate) to the following 10-question survey.

1. Which of the following best describes the industry that your business (or non-profit or public agency) is a part of?

[Options included all two-digit NAICS industries, plus some three-digit industries where the distinctions between, say, “Retail, clothing and accessories” and “Retail, food & beverages” could have been helpful.]

Industries describing the respondents businesses were:

Agriculture, forestry, fishing and hunting	(n=2)
Arts and entertainment (galleries, theaters, etc.)	(n=1)
Construction	(n=1)
Information (publishing, motion pictures, internet hosting and content)	(n=1)
Manufacturing, apparel	(n=1)
Manufacturing, Other	(n=1)
Manufacturing, wood Products	(n=1)
Other services	(n=1)
Professional, scientific, and technical services (law, accounting, etc. not health)	(n=1)
Recreation, guiding and outfitting	(n=7)
Retail, clothing and accessories	(n=1)
Retail, food & beverages	(n=2)
Retail, sporting goods (which may include clothing)	(n=7)
Other or Combination	(n=4)

2. Which of the following best describes your role in the business/organization/agency?

Owner/Co-owner	(n=26)
Senior Manager	(n=2)
Employee	(n=3)

3. How many FULL-TIME employees did the company have in 2016? (Include yourself if applicable.) Please count only those who worked full-time and year-round.

1-4	(n=19)
5-9	(n=3)
10-19	(n=6)
1,000 or more	(n=1)
No answer	(n=2)

4. How many PART-TIME employees did you have in 2016? (Include yourself if applicable.) Please count employees who worked less than full time AND those who worked any number of hours per week, but for less than the full year.

1-4	(n=10)
5-9	(n=7)
10-19	(n=6)
20-49	(n=2)
50-99	(n=1)

1,000 or more	(n=1)
No answer	(n=4)

5. Gross Sales: What was the level of your gross sales (or if an organization or agency, what was your budget) in 2016? Remember, your answers are confidential and will be used only as part of aggregate measures (averages, etc.).

Less than \$100,000	(n=6)
\$100,000 - \$500,000	(n=12)
\$500,000 - \$1 million	(n=5)
\$1 - \$5 million	(n=6)
More than \$100 million	(n=1)
No answer	(n=1)

6. How would you rate your awareness of/knowledge about the issue of sulfide-ore copper mining in the watershed of the Boundary Waters, and your level of engagement (talking about, writing letters, reading up on, etc.) related to the issue?

Average of 8 (range 5-10, n=31) on a 0-10 slider, where

0 corresponded to "I have not heard much or anything about it."

5 corresponded to "I am pretty well informed about the issue, but I am not actively following or taking any action related to it.", and

10 corresponded to "I know a lot about the issue, and I am regularly engaged in conversations and actions related to it."

7. Scenario 1: If sulfide-ore mining is NOT APPROVED and the economy of the Arrowhead region (St. Louis, Lake and Cook Counties) continues to develop as it has over the past 30 years, what are your expectations for how YOUR OWN business/organization/agency might change over the next 5-10 years?

Average of 7 (range 5-10, n=31) on a 0-10 slider, where

0 corresponded to "We expect to shut-down/ go out of business."

5 corresponded to "No change: we're about the right size.", and

10 corresponded to "We plan to expand by 100% (double in size) or more."

8. Scenario 2: If sulfide-ore copper mining WERE TO BE APPROVED in the watershed of the Boundary Waters, how would you expect YOUR OWN business/organization/agency to change over the next 5-10 years?

Average 4 (range 2-10, n=31) on a 0-10 slider, where

0 corresponded to "We expect to shut-down/ go out of business."

5 corresponded to "No change: we're about the right size.", and

10 corresponded to "We plan to expand by 100% (double in size) or more."

9. For the second scenario please describe HOW you would expect sulfide-ore mining in the watershed of the Boundary Waters to affect your outlook and your plans for your business or organization.
10. Please use this space for anything else you would like to say about the current and future business climate, economic development, or the prospects for your own business as it relates to sulfide-ore copper mining proposed for the watershed of the Boundary Waters.



Research and strategy for the land community.

27 February 2018

Constance Cummins
Forest Supervisor
Superior National Forest
8901 Grand Place
Duluth, Minnesota 55808-1122

Re: Northern Minnesota Federal Minerals Withdrawal EA

Thank you for this opportunity to comment on the proposed withdrawal of certain federal lands in the Superior National Forest from the federal minerals program. My colleagues and I have examined questions related to the lease withdrawal from an economic perspective, and with this letter we are sharing some of our key findings. Namely, we find that proceeding with the withdrawal of these lands would support significant economic benefits to the Arrowhead region comprising St. Louis, Lake, and Cook Counties, Minnesota. These benefits come in the form of avoiding damages that sulfide-ore copper mining could do to the region's existing diverse and stable economy. To put it the other way around, the mineral withdrawal would support the continued development of an economy based on sound stewardship of the Boundary Waters.

In contrast, estimates of the cost of the withdrawal, in terms of local employment and income in mining, are, at best, exaggerated. Technological and other changes in mining would blunt gains in local employment associated with sulfide-ore copper mining. And based on the track record of analyses purporting to measure future economic impacts of the mining industry, mining proponent's arguments to the effect that the region needs to keep these lands open to more mining in order to have sufficient jobs, income, or tax revenue in the future are not credible.

Economic benefits of the proposed withdrawal would be significant.

Under the National Environmental Policy Act (NEPA), the USDA Forest Service must consider the economic effects of the proposed withdraw of land from the mineral leasing program alongside ecological, aesthetic, historical, social, and health effects (40 CFR 1508.8). The salient economic effects of this action would include, as a benefit to society, the avoidance of costs associated with actual and potential sulfide-ore copper mining that, absent the proposed federal mineral withdrawal, could proceed in the watershed of the Boundary Waters. In our report dated October 2017 and attached to this letter, we presented evidence regarding those avoided costs, including conservative quantitative estimates of a small subset of them. These include

- A decline in spending as potential visitors choose alternative destinations with high quality scenic and recreational amenities undiminished by nearby mining activity. We estimate an annual loss of \$288 million in spending that would otherwise support 4,490 local jobs, \$76 million in residents' income, \$31 million in state and local taxes, and \$181 million in proprietor's income and business-to-business transactions
- 5,066 to 22,791 lost jobs, and between \$402 million and \$1.6 billion in lost annual income in the rest of the three-county Arrowhead economy if sulfide-ore copper mining suppresses or reverses growth in the amenity-based economy that has been the backbone of the region's recovery since the early 1980s

- \$509 million in lost property value. This is a one-time drop in asset value that will spawn annual reductions in local property tax revenue throughout the three-county Arrowhead region.

By implementing the mining withdrawal, as proposed, these and other costs would be avoided, thus delivering a benefit to the American people and Minnesotans equivalent to a one-time payment of more than \$6.1 billion.¹ In addition, the mining withdrawal could save between 9,556 and 27,281 jobs. (Please see the full copy of the report, attached, for details on the methods and results.)

Clearly the economic costs of sulfide-ore copper mining (or the economic benefits of withdrawing lands from the mineral leasing program) are significant and worthy of consideration as part of the NEPA review.

Costs of the withdrawal are overstated.

Just as the external costs of sulfide-ore copper mining count among the benefits of withdrawing land from the mining program, the benefits in terms of prospective regional jobs and income stemming from mining activity that might otherwise ensue should be considered among the costs of the proposed withdrawal. Mining proponents (or withdrawal opponents) have made three claims about the possible jobs and other economic effects of mining:

1. Mining and will, on net, do more for the regional economy than tourism.
2. Mining will increase employment opportunities for existing residents of the Arrowhead region.
3. Every mining job will be a good one, at least in terms of average wages.

These contentions are dubious for several reasons. First, comparing the number of jobs in mining to jobs in recreation and tourism is spurious. The study summarized above and numerous previous studies demonstrate that many sectors, not just recreation and tourism, thrive when a region takes care of its quality of life, including its scenic, aesthetic and recreational amenities.

Visitors do flock to the Boundary Waters, and those visitors do spend more than a billion dollars per year in the Arrowhead region. But as importantly, if not more so, the Boundary Waters attracts long-term residents, including retirees, entrepreneurs, and workers in many industries. These people choose to live in areas with year-round opportunities to enjoy the same amenities that visitors experience for a week, or a season each year, or once in a lifetime. The Boundary Waters is a major attraction for new residents of many industries who choose quality of life as a determining factor on place to live. (See, for example, Ronnader, Wentz, and Hove (2014), Florida (2000), and Niemi and Whitelaw (1999).)

A better comparison, therefore, would be between mining jobs that might accompany and expansion of mining and all of the jobs—in manufacturing, in professional, health, and other services, as well as in recreation and tourism—that would not leave the region or never arrive if sulfide-ore copper mining were to begin.

Decision makers including the Forest Service, should also recognize that mining represents a small minority (2.5% of jobs and 6.9% of income in 2015, down from 10% of employment and 20% of income in 1980) of the Arrowhead region's natural-resource-based economy. Other uses by visitors, amenity migrants, and long-term residents who might quit the region over concerns about the negative consequences of sulfide mining

¹ This is the present discounted value of the stream of future benefits (costs avoided) over the proposed withdrawal period of 20 years, and using the 0.2% discount rate recommended by the Office of Management and Budget for such analyses (2017).

(Ronnader and Wente, 2014), are equally or more important to the future of the region from an economic perspective.

In spite of these facts, a small minority of comments submitted to the Forest Service² do claim that mining should be permitted to proceed because, the commenters contend, mining contributes more to the Arrowhead region economy than the many industries that rely on the region's economy. These comments often include false or misleading statistics. For example, a resident of Ely Minnesota claims that a single mining company's annual payroll of \$205 million is "4 times the amount" for tourism (Cole 2017). The writer, however, is comparing the mining company's payroll to a very narrowly drawn estimate of earnings associated with visits to the Boundary Waters Canoe Area Wilderness itself, not to the tourism across the region that could be adversely affected by new mining activity. In fact, visitor spending in the Arrowhead tops \$1.1 billion per year (in 2015 dollars), a figure that includes almost \$300 million in wages and salaries of that industry's workers, and millions more earned by recreation/tourism business owners (Phillips and Alkire, 2017, p. 15).

Second, the claims of increased mining employment must be viewed in light of an accelerating trend of decreasing labor-intensity in the mining industry. Mining is becoming more capital-intensive due to a new wave of innovation in which autonomous and remotely controlled machinery is operated by a few individuals who may be located far from the mining site (MacLean Engineering, 2017). Rio Tinto, BHP Billiton, and Suncor, to name a few examples, use autonomous, driverless ore trucks. Robotic drills and other automated equipment are also becoming more prevalent. In the case of Rio Tinto, its fleet of robotic trucks and robotic trains is monitored from a control center 750 miles away from the mine. The company correctly sees automation as a way to increase efficiency and reduce mining staff (Simonite, 2017)

One mining company, Anglo American Plc., notes that automation will make the future mining industry "unrecognizable" to people who know it now. In the company's view, "the 'employee of the future' will only need to focus on managing the company's relations with governments and communities that live near its ("Robots will run mines within the next decade, Anglo says" 2017)". While this may be good news for corporate lobbyists and PR practitioners (and for those who design and manufacture mining robots), the replacement of humans with automation in the operation of trucks, crushers, and drills does not augur well for of rank-and-file miners who will see the number of their jobs dwindle even as mining continues.

This leads to the final claim commonly made by mining proponents: that any and all new local mining jobs that come with sulfide-ore copper mining will be high paying. Especially given the trend toward automation and the increasing capital-intensity of mining, not only are the absolute number of jobs per mine and jobs per ton of ore processed likely to decline, but also the higher paying jobs of the future are likely to skew more and more toward professional, engineering, and managerial positions and away from less skilled positions. Those jobs will also be less likely to be needed in or near the communities where mines are located. The reality is that mining jobs in the future will become increasingly scarce and less and less available to local people.

Because of the changes affecting mining employment, estimates made today are simply not reliable as indicators of what mining may have to offer 20, 10 or even 5 years from now. This is especially true when the estimates are derived from outmoded empirical models whose concepts, assumptions, and underlying data preclude consideration of the sort of changes just described. The attached report by Phillips and Alkire (2017), especially the section titled "Beyond Folk Economics" (pp. 2-4), includes a review of the shortcomings of the use of input-output models such as IMPLAN to predict future employment and income in a dynamic economy. In

² Based on our computer-assisted review of more than 81,032 comment letters (does not count postcards and petitions), 1.5% of commenters opposed the withdrawal and cited economic reasons for their opposition. An additional 0.3% opposed the withdrawal for other reasons. The remaining 98.2% of comments favored the withdrawal.. O

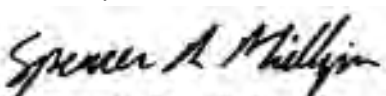
brief, while input-output models may have some value in describing current relationships among industries, they are practically useless for predicting outcomes more than a year or so into the future.

This is an important consideration, because several mining proponents cite IMPLAN-driven estimates from a University of Minnesota at Duluth (UMD) report on the economic impact of mining in their comment letters (Skurla et al., 2012). We reviewed that the report soon after its publication and found that, in addition to the general problems associated with using IMPLAN to predict future economic effects, the study had several technical errors that render its results suspect as part of an analysis of the costs and benefits of the proposed mineral lease withdrawal. For example, the UMD study defines a study region that is much larger than the region for which the lease withdrawal is proposed. Larger geographic regions naturally have more “local” spending, and that causes computed input-output multipliers to be larger than would be expected for the region of interest here—that is, St. Louis, Lake, and Cook Counties. (See Hjerpe and Phillips, 2013, attached, for the complete review.)

Further, and to the previous point regarding the inability of input-output models to forecast future effects, an earlier, 2009 version of the UMD study had predicted an increase of more than 2,000 direct non-ferrous mining jobs between 2007 and 2013 due to then-proposed non-ferrous mining expansions (Skurla et al. 2009, p. 48). What actually happened during that time period, however, was a large decrease in the number of those jobs. Baseline employment in non-ferrous mining fell from 531 jobs in 2007 to 175 jobs in 2013—a 67% decrease and a stunning contrast to the 298% increase predicted by the IMPLAN model and the authors back in 2009 (Skurla et al., 2009, p. 48; Skurla et al., 2012, p. 33). This precipitous decline demonstrates that new mining projects may not deliver new employment as mining proponents claim. Moreover, this result is emblematic of the lack of accuracy in UMD’s projected economic impacts.

In summary, we urge that the Forest Service carefully consider the true potential economic effects of the minerals withdrawal proposal. The evidence shows that the region has built a vibrant and diverse economy based on quality of life and quality of the environment. That economy would be put at significant risk if the withdrawal is rejected and sulfide-ore copper mining proceeds. There is, meanwhile, little reason to believe that mining will provide long-term gains sufficient to justify the sacrifice of the existing and future sustainable economy.

Sincerely,



Spencer Phillips, Ph.D.

Enclosures:

Hjerpe, E., and Phillips, S. (2013). *A Review of “The economic impact of ferrous and non-ferrous mining on the State of Minnesota and the Arrowhead Region”*. Charlottesville, VA: Key-Log Economics. 10 pp.

Phillips, S., and Alkire, C. 2017. *Sulfide-Ore Copper Mining and/or A Sustainable Boundary Waters Economy: The Need to Consider Real Tradeoffs*. Charlottesville, Virginia: Key-Log Economics. 42pp.

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Sulfide-Ore Copper Mining
and/or
A Sustainable Boundary Waters Economy:
The Need to Consider Real Tradeoffs

Spencer Phillips, PhD

Carolyn Alkire, PhD

October 2017

Prepared for:

Northeastern Minnesotans for Wilderness



Research and strategy for the land community.

EXECUTIVE SUMMARY

The USDA Forest Service is considering how to analyze the environmental impacts of the proposed withdrawal, for up to 20 years, of 234,328 acres of federally-owned lands within the watershed of the Boundary Waters Canoe Area Wilderness (BWCAW) from the federal mining program (USDA Forest Service, 2017). Because environmental impacts include effects on the economy, the question of how many jobs might be created by new mining activity in the Arrowhead region (defined here as St. Louis, Lake, and Cook Counties, Minnesota) is important. Equally important, but something that has so far been lost in the debate, is how many jobs and how much income in other sectors, and how much economic value that may not show up in job and income statistics—what economists refer to as “non-market” value (Stout, Winthrop, & Moore, 2015)—could be destroyed by the introduction of novel mining activity.

Proponents of *sulfide-ore copper mining* argue that the choice between this new type of mining and amenity-based development is a false choice for the Arrowhead region (Praxis Strategy Group, 2017). Those making this claim point to the continued existence of the *taconite mining* industry during the now decades-long expansion of amenity-based development in the region as proof that northeastern Minnesota can, in essence, “have it all.” According to this argument, the region can gain a relative handful of higher-paying jobs in mining; it can continue to have an abundance of high-quality recreational, scenic, and environmental amenities; and it can have jobs, income, and quality of life that exist in the region because of those amenities.

If the proposed sulfide-ore copper mining raised only the same environmental concerns as taconite mining and/or the sulfide ores were located as far away from the Boundary Waters as taconite mining and not within the BWCAW watershed, this argument might warrant consideration. But sulfide-ore copper mining presents more serious risks, such as acid mine drainage, and it would introduce risks in and around the Boundary Waters—the area that represents and produces those high-quality natural values that are the foundation of the region’s new economy. It is therefore far more likely that the “false choice” argument is itself false. There are two primary reasons:

First, the “we-can-have-it-all” claim relies on a distorted picture of the economy in which the size and importance of mining is inflated relative to the size and importance of the amenity-based development that sulfide-ore copper mining may disrupt. This distorted picture comes from studies that focus only on the economy’s exports (whether mining or tourism experiences) to the exclusion of other important facets of the economy. Those studies rely on a model of economic development that is decades, if not generations, behind the times. The studies incorrectly assume that only sales to buyers from somewhere else—for example, a steel mill or a vacationer from out-of-state—bring revenue to or support jobs in the local and regional economy. Such studies count jobs in the mines or at a resort, but they ignore jobs and income that exist in Arrowhead region due to what is known as “amenity-based development.”

Amenity-based development is economic activity in a host of industries, including recreation/tourism, construction, personal and professional services, retail, and others that arrives or stays in a region for the sake of its scenic, recreational, environmental, and quality-of-life amenities. These amenities induce an in-migration (and support the retention) of human capacity (entrepreneurs, skilled workers) that is the real engine of economic development. Amenities also attract and retain consumers, including retirees and working-age people who could do their jobs anywhere, but who would prefer to live in a place with a high quality of life.

In a world where many jobs can be done from almost anywhere, economic research must begin with an understanding of what it is that makes people choose any given location. This is not to say that the presence of a raw material is immaterial, but it does mean that, as in the days of classical economists David Ricardo and Adam Smith, one needs to pay attention to all of the factors that bestow comparative advantage on a region.

The economy of the Arrowhead Region has moved away from dependence on mining and now has a more diverse and stable economy. This has been particularly true since the early 1980s when steel manufacturing in the United States experienced significant declines that reduced demand for iron ore, including from the Arrowhead region. Structural changes in American industry, improvement in transportation, shipping, and communications networks, and new ways of hiring, working, and living have meant changes, described below, in the Arrowhead region similar to those seen in many high-amenity areas around the country. Increases in recreation and tourism are a big part of those changes, but so is the ability of people to locate their businesses and themselves where they will. While the Arrowhead still has taconite mining, forest products, manufacturing, and other “goods-producing” industries, it now relies predominately on environmental amenities and the quality of life to attract and retain business owners, workers, visitors, and retirees. Those who choose the region create and/or support jobs in diverse industries, including construction, manufacturing, recreation services, lodging and dining, and personal, professional, and educational services.

Second, the “we-can-have-it-all” claim is based on a false assumption that all mining, no matter what type or where it occurs, is compatible with all recreation, tourism, and other amenity- and/or quality-of-life-driven development. Taconite mining (particularly in places farther away from the BWCAW, its gateway communities, and from watersheds that give the Boundary Waters its name and its scenic and environmental quality) is not the same as sulfide-ore copper mining in the Boundary Waters watershed, on those communities’ doorsteps, and among the homes and businesses that exist where they do because of that scenic and environmental quality.

It is certainly true that amenity-based development has accelerated in the Arrowhead region while mining employment has continued (albeit at a much lower level), but it does not mean that further mining for different ores and with different environmental effects would not dampen or reverse that development. Indeed, as our preliminary investigation and scenarios reported below suggest, the introduction of sulfide-ore copper mining could cost the region the unique resources that are the basis for its sustainable economic development.

In this report, we review the composition of the Arrowhead Region’s economy as it has evolved over the past several decades. We demonstrate that demographic, employment, and income trends are consistent with a now-established understanding of how rural economies actually grow. In a nutshell, people follow amenities, and jobs follow people. Or, as McGranahan, Wojan and Lambert (2010) conclude, there is a “trifecta” of attractive outdoor amenities, creative workers, and entrepreneurship strongly associated with employment and business growth in areas that would otherwise face difficult economic challenges.

Regional economic trends, explored in detail in the body of this report, are consistent with this dynamic. The Arrowhead region has seen

- steady growth in population (after an early-1980s decline),
- steady increases in employment and personal income in diverse industries,
- growth in proprietors’ employment and income, and

- increases in non-labor income (such as investment income and Social Security payments) from people who may be living in or coming to the region to retire.

Looking forward, we also consider how these trends could change with the proposed advent of sulfide-ore copper mining in the watershed of the Boundary Waters. Based on information from business owners, retirees, and others, we consider how such mining, by changing the availability of attractive amenities and changing the quality of life, could change the trajectory for future prosperity in the region. We consider impacts on the recreation and tourism industry, on the broader amenity-based economy, and on the land values that may be diminished due to proximity to potential mining activity.

As explained below, based on conservative assumptions, sulfide-ore copper mining in the watershed of the Boundary Waters could bring the following effects for the three-county Arrowhead study region:

- \$288 million in lost visitor spending each year that would otherwise support
 - 4,490 local jobs
 - \$76 million in residents' income
 - \$31 million in state and local taxes, and
 - \$181 million in proprietor's income and business-to-business transactions
- 5,066 to 22,791 lost jobs, and between \$402 million and \$1.6 billion in lost annual income in the rest of the economy if sulfide-ore copper mining suppresses or reverses growth in the amenity-based economy that has been the backbone of the region's recovery since the early 1980s
- \$509 million in lost property value. This is a one-time drop in asset value that will spawn annual reductions in local property tax revenue throughout the Arrowhead region.

By implementing the mining withdrawal, as proposed, these and other costs would be avoided, thus delivering a benefit to the American people and Minnesotans equivalent to a one-time payment of more than \$6.1 billion.¹

We do not claim that these estimates are complete. Indeed, we suspect that there may be threshold effects or feedbacks that would make actual effects much larger than what we have included in the scenario. Moreover, our estimates do not include the direct costs of long-term monitoring for, and attempts to mediate the occurrence of, acid mine drainage. Nor do they include direct impacts on local governments who may face higher road maintenance, water treatment, or other costs. The estimates developed here, therefore, should be taken as a first approximation of the sort of detailed analysis the Forest Service should complete as part of its Environmental Impact Statement examining the effects of the proposed withdrawal of federal land from the federal minerals leasing program, for a period of 20 years.

¹ This is the present discounted value of the stream of future benefits (costs avoided) over the proposed withdrawal period of 20 years, and using the 0.2% discount rate recommended by the Office of Management and Budget for such analyses (2017).

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ABOUT THE AUTHORS

Spencer Phillips has been conducting and directing applied research into the relationships between natural resource stewardship, environmental quality, and human well-being for more than 25 years. He was a staff economist first at the White House Council on Environmental Quality during the first Bush Administration, and then at The Wilderness Society, where he later served as Vice President for Ecology and Economics Research. Dr. Phillips founded Key-Log Economics to help ensure that sound, independent economic research is available to those working to solve the critical environmental problems of our time. He is also a lecturer in economics, natural resource policy, and GIS analysis at the undergraduate and graduate level. Phillips holds a B.A. in economics from the University of Virginia and an M.S. and Ph.D. from Virginia Tech.

Carolyn Alkire is an environmental economist with 35 years of experience in research into the economics of land and resource management. Prior to joining Key-Log Economics, she was a resource economist with The Wilderness Society, worked for private consulting firms supporting federal agencies, and was Senior Regional Economist for San Diego's metropolitan planning organization. She earned a Ph.D. in Public Policy from George Washington University, M.S. in Economics from North Carolina State University with a Statistics minor, and B.A., *cum laude*, from the University of Richmond.

We thank Heather Meier, a volunteer with Northeastern Minnesotans for Wilderness, and John Stoner, our intern at Key-Log Economics, for invaluable research assistance.

Key-Log Economics remains solely responsible for the content of this report, the underlying research methods, and the conclusions drawn. We have used the best available data and employed appropriate and feasible estimation methods but nevertheless make no claim regarding the extent to which these estimates will match the actual magnitude of economic effects experienced if the Forest Service does not implement its proposed withdrawal of lands from the federal mining program.

THE ARROWHEAD ECONOMY

Area Overview

St. Louis, Cook, and Lake Counties make up what is called the Arrowhead Region of Minnesota (see Figure 1 below). This region boasts the natural beauty of forests and deeply interconnected streams, lakes, wetlands and groundwater. Beautiful destinations within the region include Voyageurs National Park, the Superior National Forest, and across the northern border of this region, the Boundary Waters Canoe Area Wilderness.

Reputed to be America's most visited wilderness, the BWCAW attracted 155,611 visitors in 2016 (The Wilderness Society, 2017; USDA Forest Service, 2017). The Boundary Waters contains 1.1 million acres of near-pristine water and unspoiled forests and wetlands that are as important to wildlife as they are attractive to people.

Recreational resources include 1,200 miles of canoe and kayak routes, 1,175 lakes, 12 overnight hiking trails and more than 2,000 campsites (Ely Chamber of Commerce, 2016)

The Arrowhead Region's natural landscape attracts visitors who love to hunt, hike, camp, canoe, fish, and relax outdoors in a wilderness setting. As such, the landscape is vital to supporting the tourism industry of Northeastern Minnesota.

In addition, the Arrowhead Region of Minnesota exhibits what some researchers have termed "the rural growth trifecta"—a combination of outdoor amenities, creative workers, and entrepreneurship (McGranahan, Wojan, and Lambert, 2010). The area attracts retirees, seasonal residents, those working remotely (e.g., "digital nomads"), and entrepreneurs who could set up shop anywhere but who choose to do so in places with a high quality of life.

"Minnesota is known for its north woods and clean water. Those of us that live here value that and value the fact that we can vacation in our own back yard up north. Many people have cabins or lake homes in the northern part of the state. Many people dream to retire in the area. The state of Minnesota enjoys a very healthy diversified economy. I believe this is possible because of what our state has to offer to prospective businesses and talent they can bring to the state because of our quality of life."

--Retail Business Owner (Anonymous Survey)

TRANSFORMATION OF THE ARROWHEAD ECONOMY, 1970-2015

The Arrowhead Region (St. Louis, Lake, and Cook Counties) in Northeastern Minnesota is home to a large taconite mining industry once understood to be *the* major driver in the local economy. In 1970, one in ten jobs and 15 cents per dollar of income earned were in the mining industry. Decline in the U.S.-based steel industry meant less demand for iron ore and, by the mid-1980s, the mining boom in the Arrowhead had ended. Automation has increased per-worker productivity, and mining's contribution to Minnesota's Gross State Product has stabilized, hovering around 1% over the past two decades (Cao and Tate, 2016, with Minnesota data downloaded from <https://bea.gov>). The other side of the productivity coin, however, has been a continued, steady decline in employment, and today fewer than 3 in 100 jobs and less than 5 cents per dollar in personal income is directly attributable to mining.

Beyond “Folk Economics”

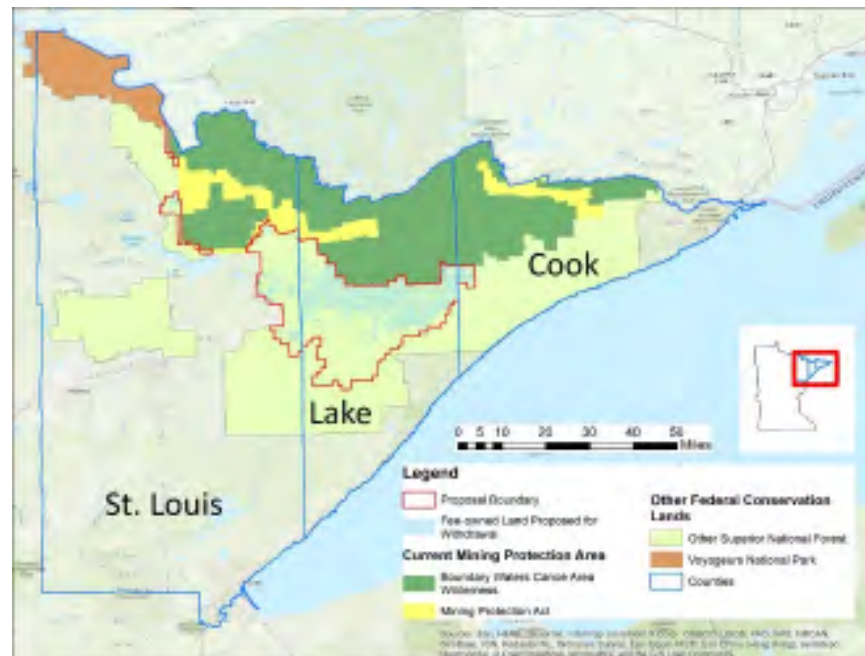
If the traditional view or “mental model” of regional economic development were still applicable, the decline in taconite mining in the Arrowhead region would doom the region to long-term decline. But such a model is, at best, out of date, and any consideration of the region’s alternative futures must be grounded in mental model, or conception, of an economy built on fundamental values in addition to the sale of material goods to other regions.

Dr. Thomas Power, in discussing the potential effects of a copper mining operation in Arizona, explains how much of our popular understanding of how economies work is rooted in “the export base view of the local economy” (2010, p 4). In this view or model, people from the local or regional area grow crops, mine for minerals, harvest timber or otherwise extract a product from the land and then export that product to another region in exchange for cash. A slightly evolved version of this model recognizes that tourism is part of the “export base” along with other goods-producing industries. The only difference is that exporting an experience (i.e., tourism) requires the buyer to come to the region, leave his or her money behind, and then take the experience home with them. In this model, that initial export transaction is the basis for all other economic activity, because the farmer, the miner, the logger, and the tourism provider all have to employ local people as laborers and buy various goods and services from other local businesses. The lumberman may hire a trucking company and buy equipment, the farmer may hire a farmhand and buy seed, and the tourism provider hires staff and buys provisions to outfit visitors’ trips into the backcountry. Empirical versions of the economic base model, generically known as “input-output models” combine the effects of spending by the employees of the exporting businesses with spending by the employees of the businesses that serve the exporting businesses to generate estimates of “multiplier effects”. These multipliers purport to show how much “output” in the form of jobs or income the region gets as a result of the initial “input” of spending on the exported goods or services. There is a limit to these rounds of impacts, because eventually some business or household is going to IMPORT a good or service from somewhere else and dollars that had been circulating among local firms “leak” out of the local economy and go on to stimulate some round of spending in another region.

There are many things wrong with this conceptual model and many more wrong with the empirical input-output models used to estimate impacts and multipliers. Not least of these, are that the empirical models have little predictive power (Krikelas, 1991) even in cases ideally suited to their

Figure 1: The Arrowhead Region

Public Lands, including the Boundary Waters Canoe Area Wilderness, and Areas Proposed for Withdrawal from the Federal Mining Program.



Sources: USDA Forest Service; U.S. Bureau of the Census; ESRI base map.

underlying structure and assumptions (Roberston, 2003). It has been 32 years since H.W. Richardson looked and concluded that 40 years' experience with economic base models [to that date] "[had] done nothing to increase confidence in them". In addition, he concluded that it would be hard to "resist the conclusion that economic base models should be buried, and without prospects for resurrection (Richardson, 1985)." Nevertheless, consultants and others persist in using these models because they conform to faulty, "folk-economic" assumptions and they provide the impressive sounding answers that those promoting various development schemes, tax breaks, or other policies may want decision makers or the public to hear.

Fundamentally, however it is not the export of goods, services, or experiences that determines the economic fortunes of a region. Rather, it is the underlying productive capacity of all of the region's resources. It is the combination of natural capital with the creativity, energy, and spirit of the people occupying those places. (Natural capital capacity for natural systems to provide food, raw materials, clean water, pleasant scenery, and recreational opportunities, among other "ecosystem services" essential to the health and well-being of people (Farley, 2012))

If the economic base model's assumption that "people will simply go to where the jobs are" was true in the past, it is true no longer. Today, people can locate where they will, and given the choice, will go where the quality of life is high, even if that means accepting a lower cash income. Niemi and Whitelaw call this getting a "second paycheck" in health, recreational access and other values, that compensates for the income they give up by not moving to a less desirable location (1999, 18). (See also Roback (1982 and 1988) for earlier statistical analysis of this phenomenon.) Moreover, businesses are comprised of people, and the people who are business owners and managers often choose to locate their business in places that offer a high quality of life, and where they can find workers who appreciate that second paycheck.

Power (2010) puts it this way:

Areas that have mixes of qualities that make it easy for those areas to attract and hold residents, will have a relatively large, diverse, and skilled workforce available at a somewhat lower price. Alternatively, such areas can get workers to move to the area without wages being bid up significantly. That makes such areas attractive to businesses. The fact that businesses are run by people who also have preferences about where they and their families live, only adds to the economic importance of a community's attractive qualities (p. 3).

He concludes that an appropriate and adequate evaluation of the impact of economic changes (Power happened to be writing about potential copper mining as well) must consider the supply side of the labor market and not just the demand for labor "created" by export-oriented development. Because it is the supply of labor attracted to a region that matters most to the region's development, this newer model of regional development is typically called a "supply-side" model.

Amenity-based development has taken the place of mining as the engine of economic development in the Arrowhead region. Amenity-based development is economic activity connected to a region's scenic, recreational, environmental (clean air, clean water), and other quality-of-life assets. Amenity-based development extends far beyond the recreation and tourism industries to any good- or service-producing industry that sells homes, cars, personal or professional services, food, etc. to people who move to, or stay in, a region because of its scenic beauty, quality of life, and in the case of the Boundary Waters, unique, world-renowned recreational opportunities. Construction, medical and financial services, all manner of retail, and other diverse industries are all contributors to (and beneficiaries of) the amenity-based economy of the Arrowhead region.

This new economy still has an export component: when people from outside the region come to Ely or Grand Marais to visit, they take away the experience and the memory of the landscape, and share it with others who may be convinced to visit. Unlike mining, such use of the landscape's scenic, recreational, and other amenities can be repeated indefinitely without fundamentally altering the landscape or diminishing its capacity to supply similar values to future visitors or future generations. In other words, the Arrowhead's amenities are a resource much like minerals, with the important exception that amenities are not used up by use.

Key Trends in the Arrowhead Economy

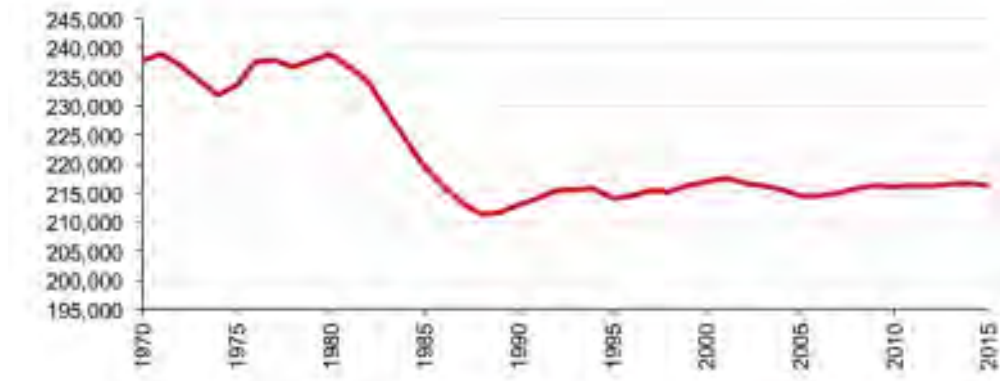
- The recession of the early 1980s coincided with a decline in mining from 10% of regional employment in 1980 to 2.5% in 2015.
- Services, including those directly connected to the region's high quality outdoor amenities (recreation and tourism) and those indicative of robust amenity-based development (construction, professional and other services) were already growing in the early 1980s and have continued to outpace all other sectors since.
- Today, more than 7 in 10 jobs are "services related."
- The fastest employment growth (since 2010) in the services category is coming from
 - information (up 13.4%)
 - professional services (up 12.3%)
 - real estate (up 12.1%)
 - educational services (up 10.0%)
 - arts, entertainment, and recreation (up 8.9%)
- The population of the three-county Arrowhead Region containing the Boundary Waters has been stable since 1990.
- Population, employment and income trends indicate the attractiveness of the Arrowhead Region to retirees and entrepreneurs.
 - Median age has increased and the largest increases in population have been among people 45 and older.
 - In 1980, sole proprietors represented slightly more jobs than mining. Today there are seven times as many proprietors as mining jobs.
 - Since 2000, growth in proprietors' employment has outpaced growth in wage-and-salary employment by a factor of 4.5 (10.3% in 2015, up from 2.3% in 2000).
 - While labor income has grown (by 8.8% since 2000), non-labor income from investments and transfer payments like social security have increased by nearly four times as much (by 33.3%).
 - Non-labor income accounts for 42% of all personal income in the region (up from 26% in 1970), with investment income and age-related transfers making up three quarters of non-labor income.
- Since the late 1980s, unemployment trends in the Arrowhead Region have tracked closely with those in the State of Minnesota as a whole.

Demographic Trends

Total Population: Decline and Regrowth

From 1970 to 2015, the total population declined from 237,809 to 216,256 people, with most of the change occurring between 1980 and 1988--a period of steep decline in mining employment. Since 1988, the population has rebounded, by 2.3% or 4,812 persons. However, from 1990 to 2014 the population of the three-county Arrowhead Region has been stable with modest growth of 2%. (See Figure 1.) (Note that these population estimates include only year-round residents, not seasonal residents.)

Figure 2: Population, Arrowhead Region, 1970 – 2015



Source: Headwaters Economics: Economic Profile System-
<https://headwaterseconomics.org/>; SocioEconomic Measures: Underlying Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Table CA30.

Age of the Population

The Arrowhead region's population is older, and, apart from St. Louis County, is getting older faster than the population of Minnesota as a whole. From 2000 to 2015, the median age in Minnesota and in St. Louis County increased by 2 years; in Lake and Cook Counties, the increase was 7 years. Within the Arrowhead region, there are fewer in the under 18 and 35-44-year-old age brackets, with gains coming in the 18-34, 45-64, and 65 and over brackets. While not definitive, the gains in the older two brackets, coupled with the region's rapid rise in age-related transfer payments (i.e., Social Security and Medicare payments--see below), suggest an increase in the number of people choosing the region for their retirement.

Figure 3: Change in Median Age, Arrowhead Counties and Minnesota, 2000 - 2015

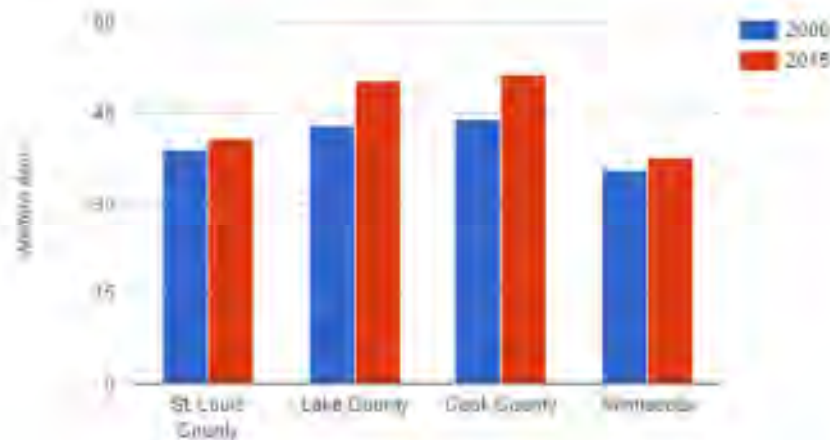
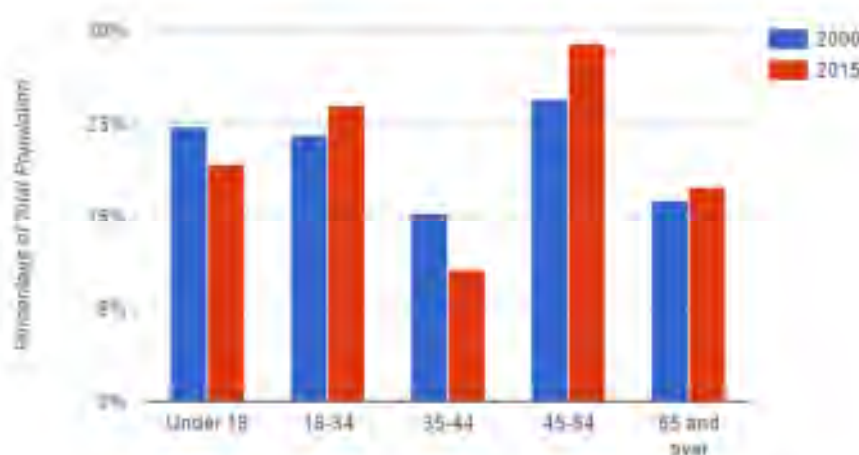


Figure 4: Age Distribution, Arrowhead Region, 2000 and 2015



Sources: US Census Bureau. (2017). American Fact Finder. Retrieved from <https://factfinder.census.gov/>; Headwaters Economics. (2017). Economic Profile System. Retrieved from <http://headwaterseconomics.org/tools/eps-hdt>

Housing

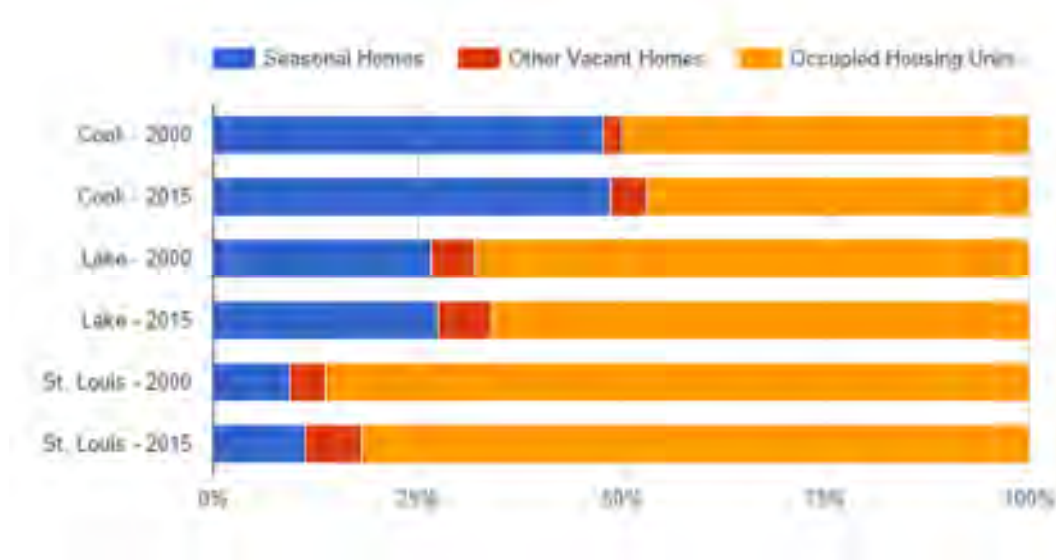
The Arrowhead region added almost 10,000 housing units (+8.6%) from 2000 through 2015. During the same period, the region's population was nearly flat (476 fewer people, or a decline of 0.22%). This seeming disconnect reveals two trends: more people are moving into their own housing units (as sign of increasing overall prosperity); and more people are building vacation homes in the region. In contrast to the 8.6% increase in overall housing units, the number of housing units for "Seasonal, Recreational, or Occasional Use" increased by 26% in the region. In Lake and Cook Counties vacation homes now comprise nearly one third and one half, respectively, of all housing units. St. Louis County, which has many more housing units to begin with, is adding vacation homes at the fastest rate (up 29% since 2000).

These housing trends illustrate the attractiveness of the region for regular visitors. It also helps explain some of the other trends we'll describe below, including increases in jobs and income in construction, real estate, and a host of other industries that people would use in the course of purchasing land,

building a home, and then using it repeatedly over the course of years. Groceries, utilities, home maintenance, health care while in the region, restaurant meals, and others are all part of the package when people invest in a region based on its quality of life.

The housing trends may also be a harbinger of still more future growth, if the current owners of homes for seasonal or occasional use become full-time residents. Some of these owners could be looking ahead to converting the homes for retirement use, and some may decide to move their job or business to the region. Either would represent important, long-term economic development opportunities for the Arrowhead region.

Figure 5: Housing Units by Type, Arrowhead Counties, 2000 & 2015



Sources: US Census Bureau. (2017). American Fact Finder. Retrieved from <https://factfinder.census.gov/>

Employment and Income

Unemployment Rate

In the mining bust of the early 1980s, unemployment rates spiked to nearly 20%. Since 1988, however, Arrowhead unemployment rates have remained much lower, and they have tracked closely with the statewide unemployment rate (Figure 6). This is consistent with what one would expect of an increasingly diverse economy. In another sign of increased resilience in the Arrowhead region since the late 1980s, recessions have not pushed unemployment as high and the recovery from them has been faster than before the mining bust (Figure 7).

Figure 6: Unemployment Rate, Arrowhead Region, 1976-2015

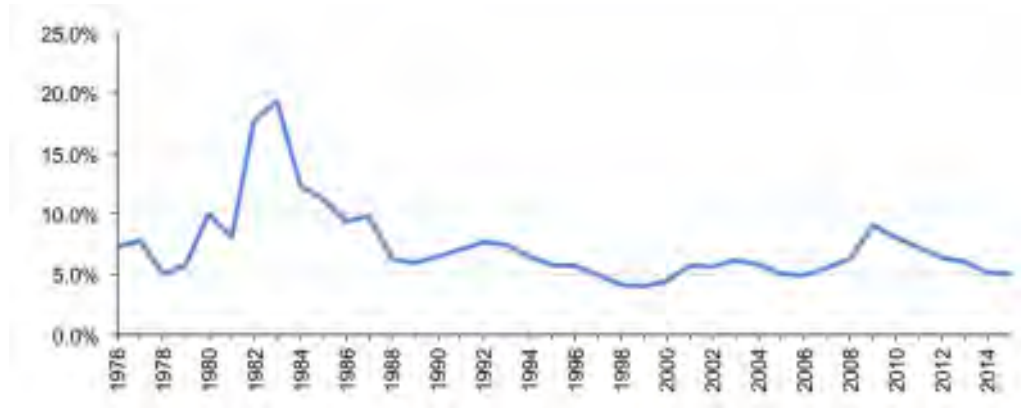
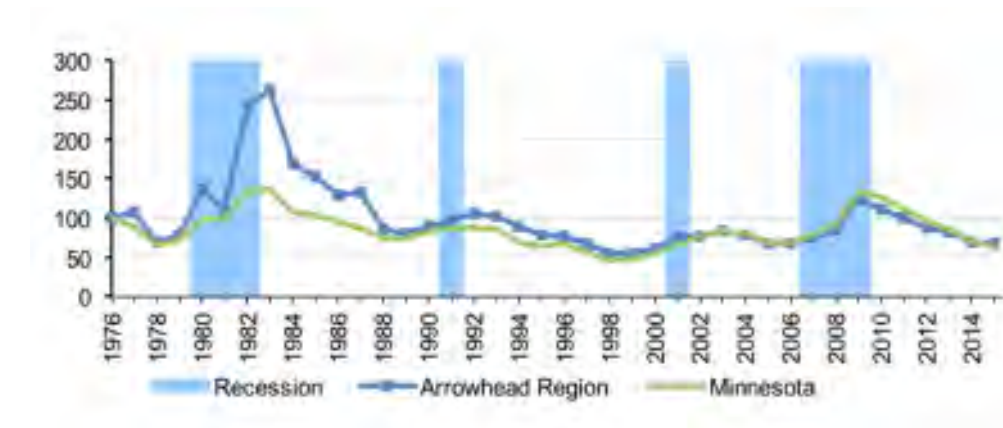


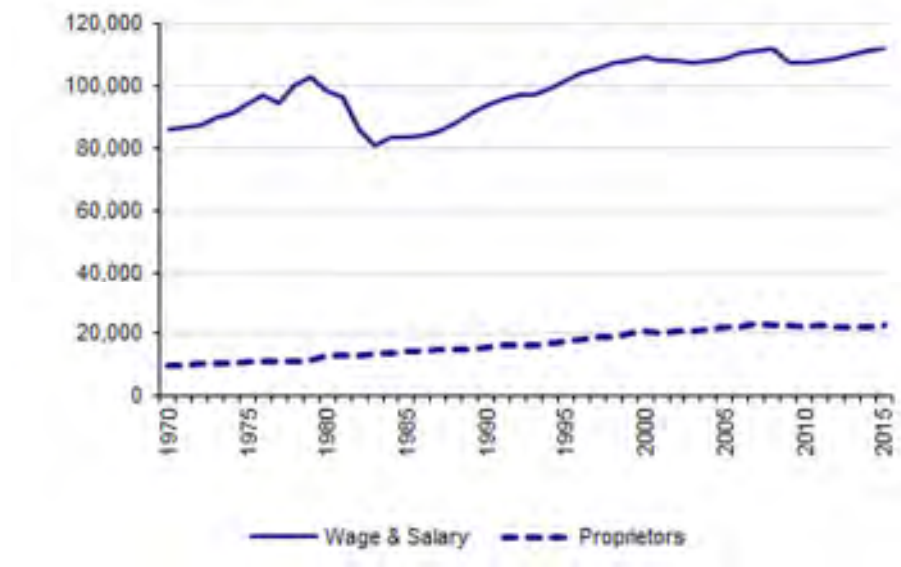
Figure 7: Unemployment Rate, Arrowhead Region and Minnesota, 1976-2015 (indexed with 1976=100)



Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>; SocioEconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Labor. 2016. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

From 1970 to 2015, total employment in the Arrowhead region grew from 95,516 to 134,402, a 41% overall increase that erased losses sustained due to the mining-led bust of the early 1980s. From 1983 to 2015 jobs grew by 39,933, a 42% increase. While wage and salary jobs (that is, working for someone else) are most common, proprietorships are growing faster--by more than 10% since 2000, compared to the 2.3% increase in wage and salary employment over the same period (Figure 8).

By 2015, one worker in six was self-employed. This concentration of proprietors indicates the region's "entrepreneurial breadth", which is one of several key rural assets that supports economic prosperity and resilience in today's global economy (Low, 2004).

Figure 8: Employment by Type, Arrowhead Region, 1970 - 2015

Source: Headwaters Economics: Economic Profile System-
<https://headwaterseconomics.org/>: Socioeconomic Measures Report: Data Sources:
 U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional
 Economic Accounts, Washington, D.C. Table CA30.

Income by Source

The income earned by wage-and-salary workers and by proprietors is “labor income”, and that accounts for 58.3% of total personal income of Arrowhead region residents. The other 41.7% is “non-labor” income and is comprised of income from past investments (dividends, interest, and rent), plus transfer payments, like Social Security and Medicare. Non-labor income has increased by a third (33.1%) since 2000, while labor income has increased by just 8.8%. Because non-labor income is attached to a person and not to a job or company, this is an important part of a region’s economic engine, and may be particularly sensitive to changes in quality of life, including the availability of recreational and environmental amenities. People can retire where they want, and, other things being equal, they are more likely to choose places with a safe and pleasant natural environment.

Earnings per job and income per person tell a similar story. While average earnings are increasing for wage and salary employees in the Arrowhead region (Figure 10), average income per person is rising much faster. Like the demographic trends, this reflects an aging population with relatively more investment and retirement income.

Figure 9: Labor and Non-Labor Income, Arrowhead Region, 1970 - 2015



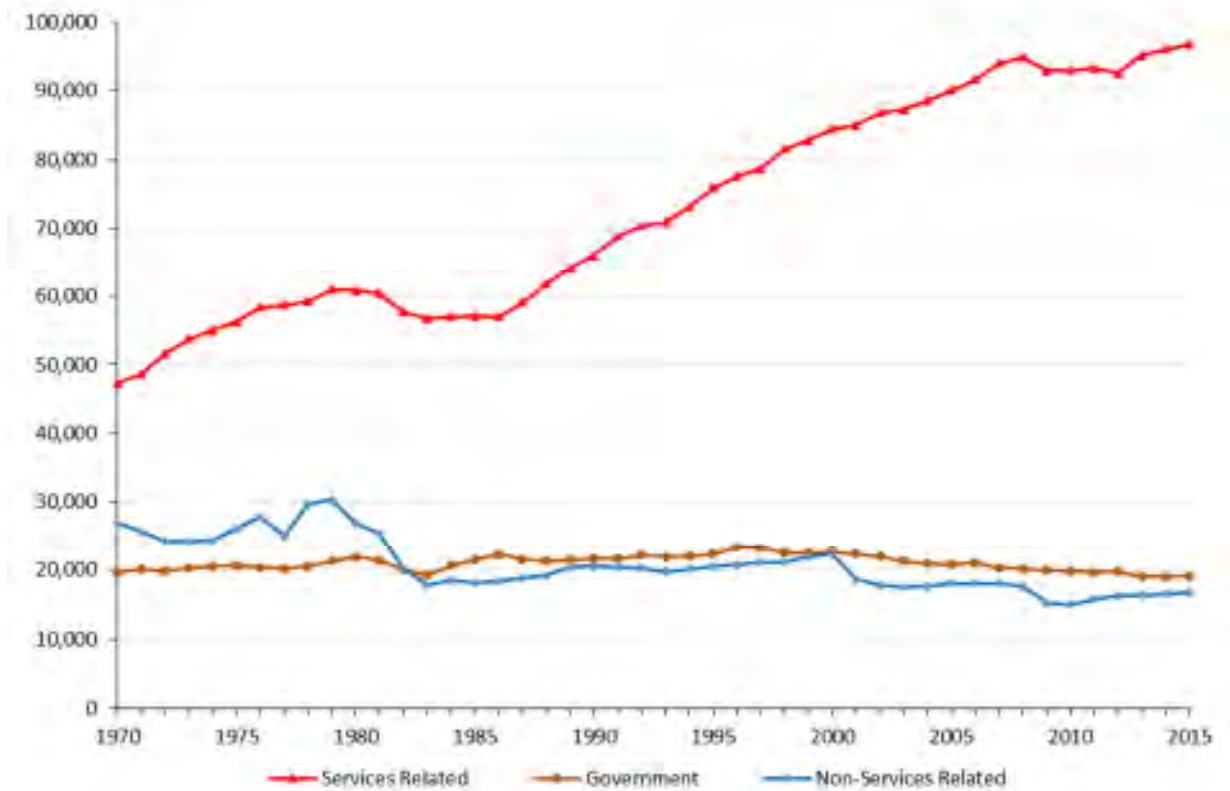
Figure 10: Earnings per Job & Per Capita Personal Income, Arrowhead Region, 1970 – 2015



Source: Headwaters Economics: Economic Profile System-
<https://headwaterseconomics.org/>; Socioeconomic Measures Report: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Table CA30.

Employment and Income by Industry

Since the decline of mining in the early 1980s, total employment in the public sector and in the goods-producing industries (farming, mining, construction, and manufacturing as a whole) has remained flat, while employment in services has grown steadily. Today, almost three out of four jobs are in services, while only one in eight is in the goods-producing industries. There are differences among the industries that comprise these broad categories, however. For example, the region has seen steady increases in construction employment, which reflects the increases in housing stock already discussed. The effects of amenity-based development, in other words, are not restricted to the service-producing sectors.

Figure 11: Employment by Major Industry Category, 1970 – 2015

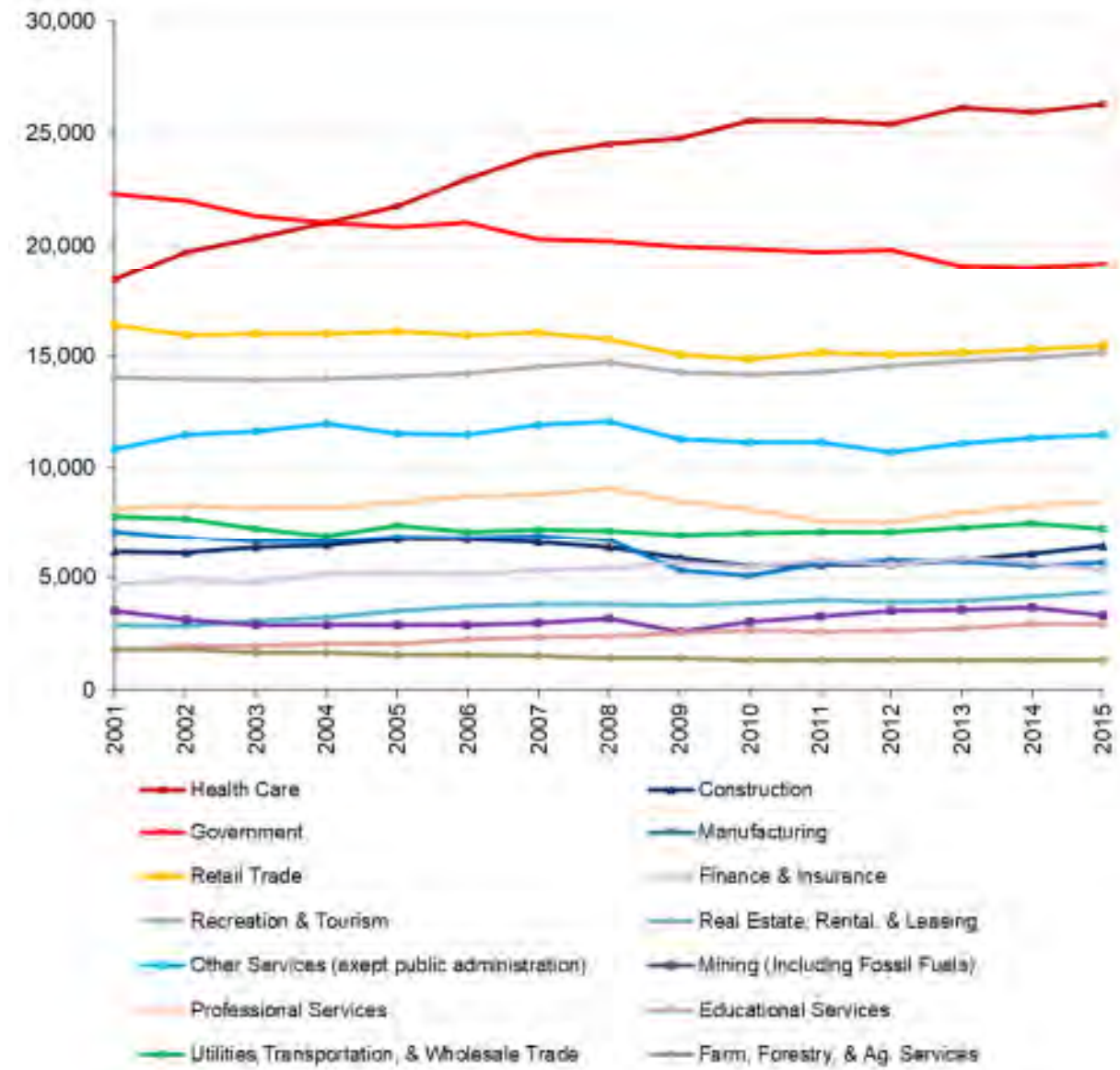
Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>; Socioeconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA25 & CA25N. The series is split at 2000-2001 due to the changes in the classification of industries that does not allow direct comparisons of all data from before and after the change.

The steady increase in the number of jobs in service-related industries, coupled with the relative stability of the Arrowhead economy since 1988 indicates the extent to which the regional economy has moved beyond mining-dependence and does not need to favor the production of material goods for export to survive. (See “Beyond Folk Economics”, page 2.) Instead, the Arrowhead region has been able to recover and prosper on the basis of diverse economic activity, much of which is directly or indirectly related to the quality of the environment more broadly.²

Recreation and tourism represents 11.3% of all jobs in the region, which are perhaps most closely tied to how visitors perceive and enjoy the region’s natural assets. Visitors also support local businesses in the retail trade (11.5%), real estate rental and leasing (3.2%), educational services (which may include camps if the camp owners self-identify their business as an education rather than a lodging business) (2.2%), and other industries. Given the number of firms making outdoor apparel and equipment, and other products used by visitors, recreation and tourism also supports and is tied to local manufacturing employment and income (4.2%).

² It is important to note, however, that there is significant variation among smaller geographic areas within the Arrowhead Region, and some communities are more or less dependent on goods-exporting industries versus service-producing industries.

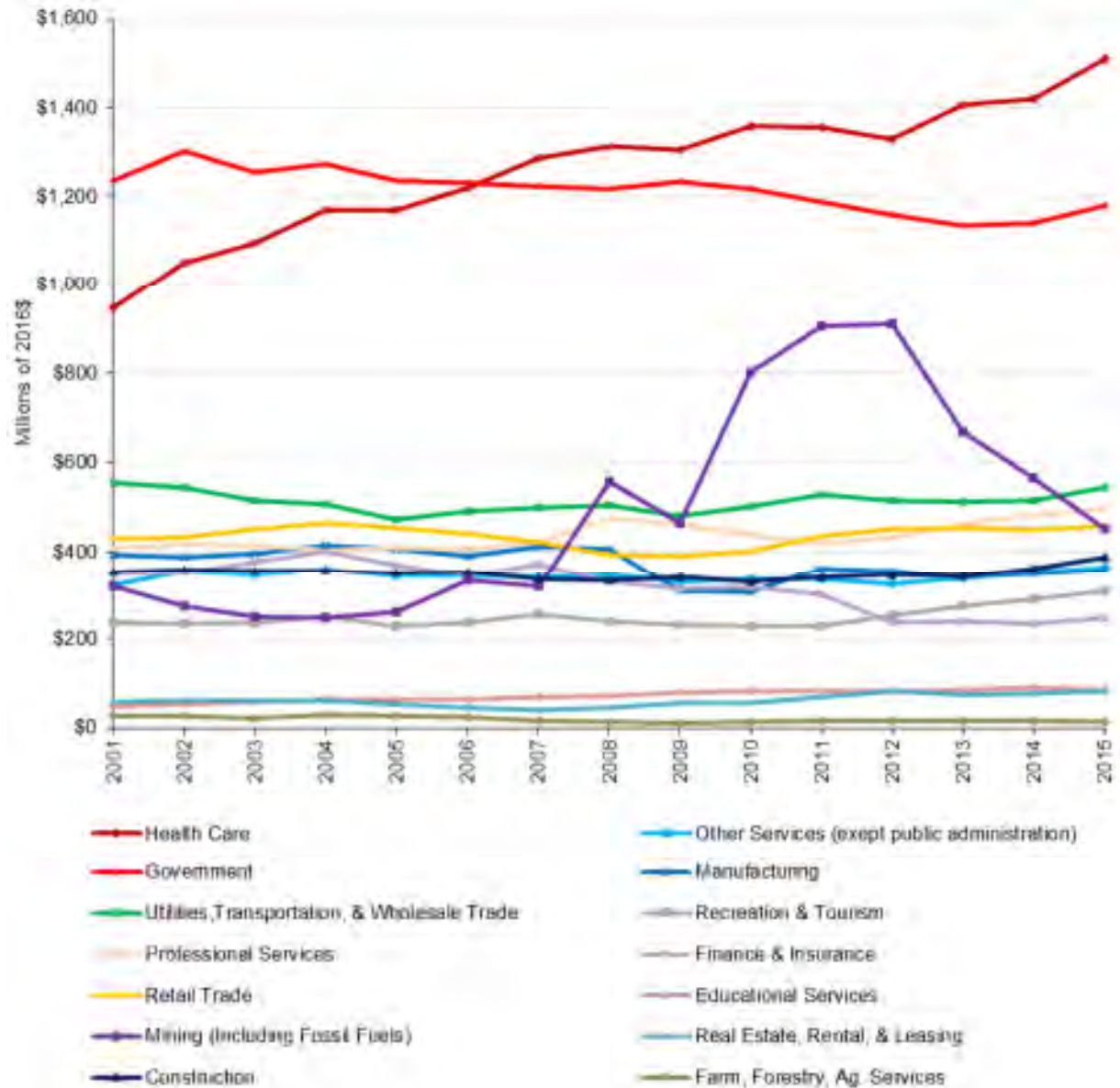
Figure 12: Employment by Industry Group, Arrowhead Region 2001 - 2015



Note: "Recreation & Tourism" includes Arts, Entertainment, and Recreation as well as Accommodation and Food Services. "Other Services" includes Other, Administrative, and Waste Services. "Professional Services" includes Professional Services, Management of companies and enterprises, and Information. "Utilities, Transportation, & Wholesale Trade" includes these categories and Warehousing. "Farm, Forestry, & Ag. Services" includes Farm, Forestry, Fishing, and Ag. Services.

Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>; SocioEconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA25N.

Figure 13: Earnings of Workers, by Industry, Arrowhead Region, 2001-2015, Millions of 2016\$



Note: "Recreation & Tourism" includes Arts, Entertainment, and Recreation as well as Accommodation and Food Services. "Other Services" includes Other, Administrative, and Waste Services. "Professional Services" includes Professional Services, Management of companies and enterprises, and Information. "Utilities, Transportation, & Wholesale Trade" includes these categories and Warehousing. "Farm, Forestry, & Ag. Services" includes Farm, Forestry, Fishing, and Ag. Services.

Source: Headwaters Economics: Economic Profile System- <https://headwaterseconomics.org/>; SocioEconomic Measures: Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA05N.

Recreation-and-tourism-driven employment and income are just a portion of the region's amenity-based development, however. Retirees and entrepreneurs who move to the region for its quality of life are perhaps even more important, because they create and support jobs in the local and broader regional economy by using health care (19.6% of jobs), professional services (6.3%), financial services

(“Finance and Insurance”) (4%), as well as services of the construction and real estate industries (8% cumulatively).

These statistics alone do not tell us many of the people behind these employment figures are located in the Arrowhead region for the sake of its environmental and other quality-of-life amenities. It is clear from other sources of information, however, that such amenities are important to decisions to move to or stay in this particular region as well as in other similar high-amenity areas (Ronnader, Wentz, and Hove, 2014; Florida, 2000; Niemi and Whitelaw, 1999; Northeastern Minnesotans for Wilderness 2016). Therefore, to mistake recreation-and-tourism as the sum total of amenity-based development would miss much of the contribution of natural capital to the Arrowhead Economy. By the same token, to compare employment, wages, and other economic impacts from mining to those in recreation and tourism alone, as in the report by the Praxis Strategy Group (2017), is to present a distorted picture of the full extent of the “opportunity cost”³ of sulfide-ore copper mining.

Trends in earnings or income by industry, depicted in Figure 13, look much like the employment trend, with the largest share of income and some of the most rapid growth occurring in services. One relevant difference between graphs is that the pronounced boom and bust in mining *income* between 2008 and 2015 does not seem to have translated into much change in mining *employment* during that time. This suggests that while those with mining jobs do comparatively well in the boom times, the boom does not do much to increase the number of mining jobs.

Visitor Expenditures and the Tourism Industry

It should be clear by now that there are many facets to the amenity-based economy of the Arrowhead region. Tourism, however, is usually the first industry that comes to mind when one thinks about the impacts of potential land use change and loss of environmental quality. In this section, therefore, we focus on the various economic effects of the attractiveness of the Boundary Waters to visitors from other places.

Unlike “mining”, “construction”, “professional and technical services”, or other industries, there is not a single industrial classification into which all facets of the visitor services industry, or tourism as we will call it from here on, fits. Rather, the tourism industry is comprised of pieces of industries that, to varying degrees, serve visitors and residents alike. Air transportation, hotels and other lodging places, and some services might be used primarily by visitors. Restaurants, guiding and outfitting services, outdoor retailers, gas stations, and grocery stores, however, serve both residents and visitors. Estimates of jobs or income by industry, therefore, need to be augmented with other data in order to get a complete picture of the tourism industry, leavened with survey data reflecting how and where tourists actually spend their money.

Those who lose with sulfide-ore copper mining would be Arrowhead, Twin Cities, and other Minnesota residents who, perhaps having chosen their location to be near the amenities of the Boundary Waters, now have to spend more time and money to get to somewhere else.

³ “Opportunity cost” is economists’ term for what a person or the economy as a whole inherently loses in making a choice between competing options. In this case, the opportunity cost of sulfide-ore copper mining would register as jobs and income in the amenity-based economy, along with other values.

Davidson-Peterson Associates conducted such a survey of visitors for Explore Minnesota Tourism in 2007 and 2008 and developed county-by-county estimates of traveler expenditures in Minnesota and the jobs, state and local tax revenues, and other impacts those expenditures support (Davidson-Peterson Associates, 2008). Of Minnesota's 87 counties, St. Louis, Cook, and Lake Counties ranked third, thirteenth, and sixteenth from the top in terms of in-county traveler expenditures. The total for the Arrowhead region in 2008 was \$1.1 billion (adjusted for inflation to 2015 dollars). These expenditures supported almost 15,800 full-time equivalent jobs, nearly \$300 million in workers' income, and \$119 million in state and local tax revenue (all in 2015 dollars). The balance, roughly \$700 million, went to other businesses and to owners of the direct tourism businesses.

To gain a more current picture of these contributions to the Arrowhead region's economy, we turn to another Explore Minnesota report conducted by Tourism Economics (2016) which estimated year-by-year expenditures and other metrics for the entire state. According to the report, statewide visitor expenditures grew at an average annual rate of 4.97% from 2009 to 2015. Starting from the 2008 base for the Arrowhead region and applying the year-by-year growth rates for the entire state, we estimate that expenditures in the Arrowhead region would have been \$1.42 billion in 2015, which would have supported 22,174 full-time-equivalent jobs, \$376 million in resident's income, and \$152 million in state and local tax revenue.

It is important to note that these estimates reflect only those expenditures by out-of-state visitors. Minnesotans residing outside the Arrowhead who visit the region to recreate in the Boundary Waters, as well as Arrowhead region residents who recreate close to home, add to the expenditure totals and further support the region's tourism industry. As discussed under "Beyond Folk Economics" (on page 2), such expenditures by in-region or in-state residents may not be considered a true economic impact because the dollars spent are already there. We contend, however, that those expenditures should be counted as part of the economic contribution of the Boundary Waters and of the natural amenities of the Arrowhead region. The reason is that Arrowhead residents and all Minnesotans can choose where to spend their recreation and tourism dollars. If sulfide-ore copper mining were to make the Boundary Waters less suitable or attractive a place to spend one's time and money, then some portion of those expenditures by Minnesotans would occur somewhere else. The Arrowhead region would lose, and another region, perhaps one that had not sacrificed its wilderness character or environmental quality, would gain. Among the losers, of course, would be those Arrowhead, Twin Cities, and other Minnesota residents who, having chosen their location to be near the amenities of the Boundary Waters, would now have to spend more time and money to get to somewhere else.

Seasonal Residents

As the information on seasonal housing on page 6 indicates, the Arrowhead region has many part-time or seasonal residents. A recent study of four townships⁴ by the University of Minnesota, Morris' Center for Small Towns (2014) reveals that seasonal residents spend an average of \$8,008 per household per year (in 2015 dollars) in the local economy. If this average is typical of the 16,357 vacation/seasonal homes across the Arrowhead region, seasonal residents would contribute some \$131 million per year to the region's economy. This spending supports businesses and employment in all industries, including construction, automotive service, medical, retail, and entertainment.

⁴ The townships included in the study are Morse, Fall Lake, Stony River, and Eagles Nest.

POTENTIAL EFFECTS OF SULFIDE-ORE COPPER MINING ON THE ARROWHEAD REGION'S ECONOMY

The current dominant narrative from proponents of sulfide-ore copper mining seems to be focused on predictions of new jobs and economic prosperity due to new mining activity without any consideration of the magnitude of the economic costs. Indeed, proponents of sulfide-ore copper mining, by claiming the region can “have it all”, espouse a view that there would be no costs at all.

Proponents of sulfide-ore copper mining would do well to recall the famous aphorism from Nobel Laureate Milton Friedman: “There is no such thing as a free lunch.” Decision makers, in other words, should not forget that there is an “opportunity cost” to the introduction of sulfide-ore copper mining into the watershed of the Boundary Waters. This cost includes lost visitor spending and the jobs and income associated with it, lost economic development throughout the economy as sulfide-ore copper mining makes the region less attractive as a place to live and do business, and lost property value as residents flood the market with first and second homes located in places where it is no longer desirable to visit or reside.

We therefore provide the following preliminary estimate for some of these key economic costs of sulfide-ore copper mining. We want to emphasize, however, that our estimates reflect only impacts on a limited number of **market** values (property value, jobs, and income) and are, therefore, very conservative estimates of the full **economic** value at stake. Economics recognizes that the dollars that change hands in the marketplace (or don't change hands, as would be the case with sulfide-ore copper-mining-induced changes in the Arrowhead economy) are just a partial indicator or reflection of the total economic value of natural resources and the environment. For every dollar paid in market value, such as for travel or lodging to recreate in the BWCAW, to buy hard goods and provisions for the trip, or to buy a seasonal or permanent home in the region, there is additional “non-market” value in the form of the traveler's/homeowner's satisfaction from the experience. For most people and for most market transactions, there is a “consumer surplus” defined as what people *would* pay for a good, service, or experience over and above what they *do or have to pay* (that is, the market price) for it.

Our estimates do not include direct costs of monitoring and attempting to mitigate potential and actual damage to ecosystems that may occur over the course of opening, operating, and in a few short years, shutting down mining operations. The need to monitor for acid drainage and other impacts would continue for decades and centuries after operations have ceased and any benefits from sulfide-ore-mining are a distant memory. In the shorter term, erosion and sedimentation, health effects of dust and light pollution, and higher maintenance costs for roads and other infrastructure would entail expenditures by individuals and local governments as well as non-market impacts on human well-being.

Our estimates below do reflect a portion of such impacts. For example, if noise, dust, and light pollution or other insults to the ecosystem service value of land near mining sites reduces the value of a seasonal or year-round home, there would be a reduction in the market price (fewer dollars exchanged) if and when the home sells. Prior to sale, however, the current owners would experience a loss of well-being or satisfaction with their home that could be greater than the eventual loss in market value.

Finally, we have not attempted to estimate losses of what are known collectively as “passive-use value”. This is the value to people of keeping places like the Boundary Waters as clean, aesthetically

appealing, and ecologically intact as possible for the sake of potential future use by oneself (“option value”) or by one’s descendants (“bequest value”). Passive-use value also includes “existence value”, which is the value to individuals of keeping places like the BWCAW intact to even if those individuals have no expectation of ever using or enjoying the place directly.

While effects on ecosystem services and drops in passive use value may be reflected in economic measures of the effects we explore below, we do not contend that we have captured the full costs, either market or non-market, of those effects. The major caveat to these estimates, therefore, is that what we “see” or estimate here may be but the tip of a very large iceberg of economic costs that are not as readily apparent, at least not yet.

What Drives Costs of Sulfide-Ore Copper Mining?

Before getting to dollar estimates of the costs of sulfide-ore mining, we must consider what may drive the decisions to come to (or not) the region to visit, to live, or to start a business or, for those who had made such decisions in the past, whether to come back to or stay in the Arrowhead region or elsewhere in Minnesota. As noted above, the Forest Service should undertake a thorough examination of the extent to which sulfide-ore copper mining would affect such decisions. As a first step in that direction, we have considered and developed several indicators of what motivates such decisions and how strong the impacts of new mining activity in the watershed of the BWCAW might be.

Many local residents have stated that the effects of sulfide-ore copper mining operations on the community and natural environment--noise, dust, truck traffic, pollution of existing high-quality ground and surface water (which supplies drinking water to many local residents), risk of damage to fisheries and aquatic habitat--would likely result in fewer visitors to the region, discourage new businesses from locating, and deter new residents. “If there were mines in the Boundary Waters, it would change the reputation of the Boundary Waters as a whole, and damage businesses” asserts Bill Hansen, an owner of Sawbill Outfitters located between Ely and Gunflint (B. Hansen, personal communication, 2016). He continued, “once a mine has been built, it is really hard to develop new businesses near it.” Steve Piragis, owner of Piragis Northwoods Company in Ely, noted that just the perception of a sulfide-ore copper mining industrial zone on the edge of town would be enough to scare off people who might visit, or build a vacation home or otherwise settle in Ely (S. Piragis, personal communication, 2016). And the owner of Hungry Jack Outfitters (on the eastern side of the BWCAW), Dave Seaton, said he feels that there would be enough impact from the mine to damage outfitting (D. Seaton, personal communication, 2016).

In addition, residents believe the existence of sulfide-ore copper mining in the region would cause some of the current residents and businesses to leave the region (see Figures 14a and 14b, below). As the area becomes (perceived to be) less desirable, the value of remaining businesses, as well as the value of both year-round and vacation properties and related property tax receipts, all are expected to decline. Dave Seaton, for one, expressed concern about land and business values if the mine comes in, because he intends to sell Hungry Jack Outfitting at some point (D. Seaton, personal communication, 2016). Sulfide-ore copper mining would, he believes, take away from the value of the business to any prospective owner and therefore reduce the prices he might be offered.

Loving or Leaving the Boundary Waters Region

Figure 14a. Loving: Why do you choose to live or own land in the four townships area?

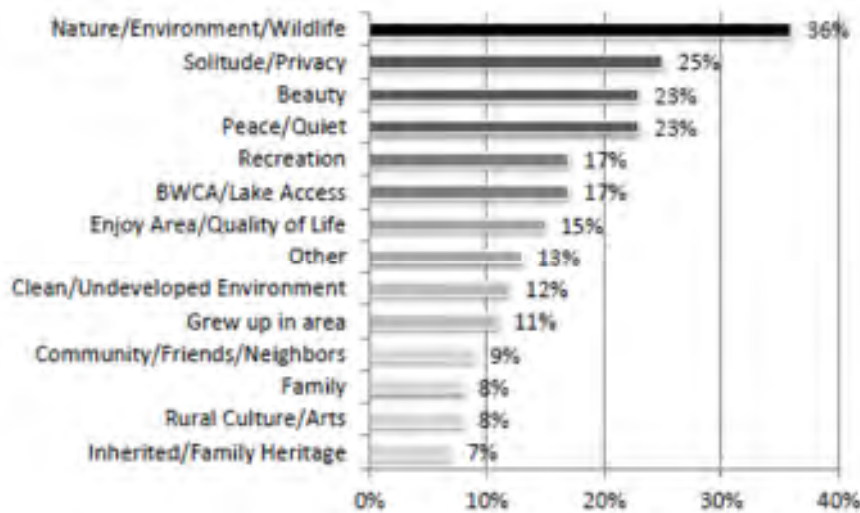
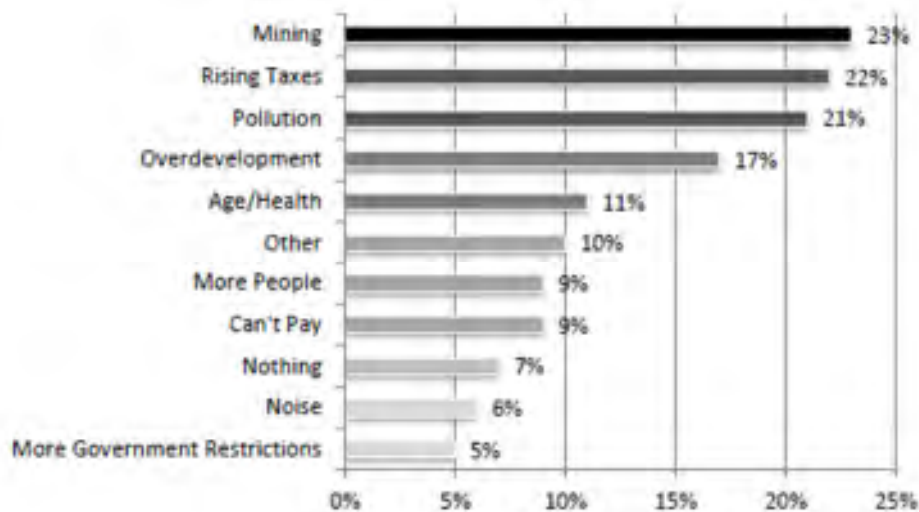


Figure 14b. Leaving: What factors would make you leave the four townships?



Source: Ronnader, R., Wentz, J., and Hove, M. (2014). *The Four Townships Area Economic, Housing Development Survey* (p. 51). Center for Small Towns and Data Services Center, University of Minnesota at Morris.

As part of *The Four Townships Area Economic, Housing and Development Survey*, researchers at the University of Minnesota, Morris asked property owners (both year-round and seasonal residents) about their reasons for owning property and/or living⁵ where they do and what might cause them to leave (Ronnader, Wentz, and Hove, 2014). The top reasons people gave for their having chosen to live

⁵ Some of the study's survey respondents owned property in the region, but do not reside there personally.

or own land in the region include “Nature”, “Beauty”, “Recreation”, “Undeveloped Environment”, and “Quality of Life” (see Figure 14a). Not surprisingly then, threats to or the loss of those amenities are among the top reasons people would leave the region. The most common reason, cited by 23% of respondents, was “Mining” (see Figure 14b). The researchers note that “a few” respondents indicated that their concern was that there are not enough mining jobs, but that mining was mentioned “mostly [by] respondents expressing [concern over] potential negative consequences from mining” (Ronnader, Wente, and Hove, 2014, p.48). The next most common reasons, each cited by more than one in five respondents, why owners and residents would leave are “Rising Taxes”, “Pollution”, and “Overdevelopment”.

Survey of Arrowhead and Minnesota Business Owners

While the “four townships” survey described above touches on the question of whether and how sulfide-ore copper mining would affect residents’ and property owners’ decisions about whether to stay in the immediate region, there has not yet been a systematic survey conducted to discern the likely effects of sulfide-ore copper mining on the outlook of businesses in Minnesota.

To be sure, businesses have spoken out both for and or against this new type of mining, and anecdotal evidence from letters to the editor, statements made at public meetings, and in other venues and documents (Northeastern Minnesotans for Wilderness, 2016) do suggest that for some businesses the advent of sulfide-ore copper mining in the Boundary Waters watershed would be catastrophic. But such data may not be readily generalizable to the whole of the economy or even to the portions that one would consider to be most directly affected by the proposed new mining industry. We therefore recommend that the Forest Service should conduct, as part of its withdrawal study, a thorough, statistically robust poll of business owners, residents, visitors, and others who have a stake in or who may hold values related to the quality of life and the quality of the environment in the watershed of the Boundary Waters.

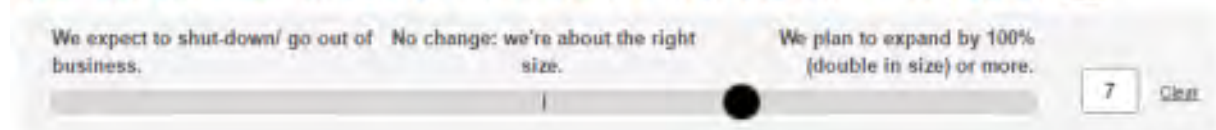
In the meantime, we have attempted to obtain and use more systematic information as part of our estimates of potential costs presented below. Specifically, we used information from three sources:

1. Personal interviews with a group of small- and medium-sized retail, recreation, and tourism business owners from Ely and Grand Marais.
2. Review of 27 sworn affidavits filed in *Franconia Minerals (US) LLC; and Twin Metals Minnesota LLC, v. United States of America: U.S. Department of the Interior; et al.* (U.S. District Court, District of Minnesota).
3. Brief, anonymous, but nonrandom survey of business owners throughout the Arrowhead region and the whole of Minnesota. The survey was sent to 140 members of the “Boundary Waters Business Coalition,” and we received 31 responses for a response rate of 22%.

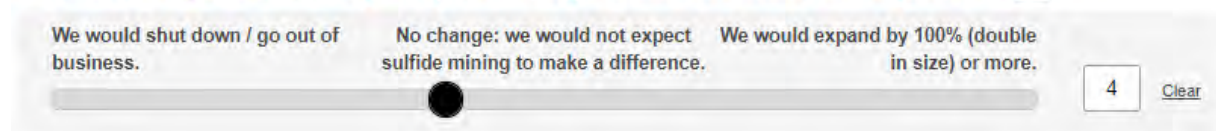
The business survey covered some basic information about each business (industry classification, size, etc.) as well as two key questions about each business owner’s (or, in some cases, a manager’s) realistic expectations for the future of their business in two scenarios: one with sulfide-ore copper mining in the watershed of the Boundary Waters, and one without. For these two questions, respondents moved a slider left or right from a “status quo” position. (See Figure 15 and Appendix A). The left and right ends of the scales represent extremes of “we expect to shut down” on the left, to “we expect to double or more” on the right. The position of the slider was automatically translated into a numerical score of zero to ten, and from this we infer a percentage change from the status quo in each scenario.

Figure 15: Survey Questions re: Business Outlook with and without Sulfide-Ore Mining in the watershed of the Boundary Waters

7. Scenario 1: If sulfide-ore mining is NOT APPROVED and the economy of the Arrowhead region (St. Louis, Lake and Cook Counties) continues to develop as it has over the past 30 years, what are your expectations for how **YOUR OWN** business/organization/agency might change over the next 5-10 years?



8. Scenario 2: If sulfide-ore copper mining WERE TO BE APPROVED in the watershed of the Boundary Waters, how would you expect **YOUR OWN** business/organization/agency to change over the next 5-10 years?



Note: The slider position and resulting numerical score (in the box to the right of each slider) show the average for the 31 responses received. We interpret the 7 in Scenario 1 (question 7), which is two steps above “No change” toward “...expand by 100%” to be interpretable as a 40% increase. Similarly, for Scenario 2 (question 8), the 4, which is one step (out of 5) toward “We would shut down...” to be interpretable as a 20% decrease.

Please see Appendix A for the complete survey.

From the survey responses we find that, on average, the businesses expected to grow by 40% over the next 5-10 years in a without-sulfide-ore copper mining scenario. In the with-sulfide-ore-copper-mining scenario, an average reduction in business of 20% over the same period is expected. We use this 20% reduction as the basis for estimates below of the effect of the proposed sulfide-ore copper mining industry on visitor spending, visitation, jobs, and income. Such a change does not seem unreasonable, given that traveler spending in Minnesota has increased by more than 20% in the past five years preceding 2016 (Tourism Economics, 2016)

This survey and the resulting estimates do have two countervailing caveats to keep in mind.

- First, a survey of business owners who have signed up as part of a coalition raising concerns about the mining proposal are more likely to be well-informed about the issue. Indeed, the respondents, on average, rated their awareness and knowledge of the issue as an eight on a zero to ten scale. To the extent that joining the coalition and being more informed on the issue correlates to opposition to the mining proposal, we would concede that the survey results are “biased” in the technical/statistical sense (i.e., we are not casting aspersions on the respondents), and we urge the U.S. Forest Service to conduct a random, statistically unbiased survey to get additional information about business owners’ and others’ expectations.
- Second, survey respondents do come from a range of industries (construction, manufacturing, retail, professional services, as well as recreation/tourism industries including lodging,

restaurants, guiding and outfitting). The respondents also do business from locations throughout the state. (The survey was anonymous, but we have information on industry category from a specific question, and we know something of the businesses' locations based on what some respondents volunteered in open-ended survey questions (see Appendix A). (As one might expect, businesses geographically closer to the Boundary Waters indicated that mining would have a stronger negative effect on their outlook than businesses down state.)

The fact that our cost estimates apply the statewide average to Arrowhead Region outcomes mitigates, at least partially, any sampling bias that may have colored the results. Moreover, we asked the business owners about their realistic expectations regarding the future of their businesses, not for their personal opinions. Interestingly, the lowest score on the question about expectations in the "with-sulfide-ore copper mining" scenario was a two (corresponding to a 60% reduction in the business). None of the respondents, in other words, indicated that they would go out of business completely. (Such expectations do show up in anecdotal information.) One business out of the 31 respondents, a small "retail/food & beverage" business, expects to double or more with or without the mine, even though they noted that sulfide-ore copper mining would hurt their sales and induce a change in focus toward other regions. That was an outlier, however: every other business indicated that it would either stay the same (8 businesses) or become smaller (23 businesses) in the "with-mining" scenario.

Estimated Costs: Three Ways Sulfide-Ore Copper Mining Would Affect the Arrowhead Region's Economy

There are at least three interrelated ways in which sulfide-ore copper mining would likely affect the economy of the Arrowhead region and, by extension, the entire state of Minnesota.

1. *Fewer visitors and less visitor spending:* The actual and perceived loss of environmental quality, including diminished quality of recreational experiences, would reduce the number of visitors coming to the region each year. That would translate into less spending, fewer jobs in all of the industries supported by visitor spending, and lower state and local tax revenues.
2. *Fewer in-migrants and more out-migrants:* The same effects on environmental quality would make the region less attractive to retirees, footloose entrepreneurs, mobile workers, or anyone else looking to reside or do business in a location with a high quality of life based on environmental factors and easy access to diverse, high quality outdoor activities (Florida 2000). As the "supply side" model of regional economic development suggests (see "Beyond Folk Economics", page 2), losing that quality of life will mean fewer in-migrants, more out-migrants, and as a result, less economic activity in all sectors.
3. *Loss of residential and commercial property values:* The value of being close to areas with outstanding natural amenities and opportunities for outdoor recreation is typically capitalized into nearby land values. As sulfide-ore copper mining reduces the amenities whose value is bound up with the overall value of residential and business properties, property value will fall, taking wealth away from current owners, and reducing local property tax revenue for years to come.

We consider each of these effects in turn.

Lost Visitor Expenditures

During a 12-month study period spanning 2007 to 2008, visitors (defined as persons staying one night or more in a location than 50 miles from their home) spent more than \$1 billion in the Arrowhead region (see Table 1, below) (Davidson-Peterson Associates, 2008). The study found that St. Louis, Cook, and Lake Counties ranked 3rd, 13th, and 16th, respectively, among Minnesota's 87 counties in terms of visitor spending. The study also broke down the direct impacts of that spending into its impacts in the regional economy. For each \$1 million in visitor spending, there were

- 16 direct jobs supported,
- \$264,666 in residents' income,
- \$106,770 in State (\$83,418) and local (\$23,352) tax revenue, and
- \$628,564 in proprietors' income and business-to-business spending

Note that these are direct impacts only and do not include "multiplier effects" that are calculated using input-output models. In this case, multiplier effects would comprise "indirect effects", which is spending by the businesses with whom the direct businesses (that is, those where the visitors spent their money) do business. Multipliers would also include "induced" effects that occur when people spend their earnings from work at businesses directly serving visitors or from work at the "indirect" businesses.

Davidson-Peterson Associates (2008) estimated total effects and found that multipliers in the Arrowhead region were 1.34 for jobs and 1.54 for residents' income and taxes. Thus, for every 3 jobs directly supported by visitor spending (in a hotel, at an outfitter, at a gas station, etc.) a fourth job would be supported in another business (for example, the outfitter's accountant, or the gas station's parts supplier). Similarly, for every two dollars spent by visitors, a third dollar would be spent in the Arrowhead economy, as the hotel manager, the outfitter's accountant, etc., spend their paychecks in the community.

Table 1. Estimated Direct Economic Impacts of Traveler Expenditures, 2008 & 2015, and Annual Losses with Sulfide-Ore Copper mining.

	Spending & Impacts, 2008	Impact per \$1 million Spending	Projected Spending & Impacts, 2015 (in 2016\$)	Losses with Mining (2016\$ & Jobs)
Traveler Expenditures	\$ 1,024,726,048	n/a	\$ 1,438,413,258	\$ 287,682,652
Jobs (full-time equivalent)	15,787	16	22,448	4,490
Resident Income	\$ 271,210,252	\$ 264,666	\$ 380,699,234	\$ 76,139,847
State Revenue	\$ 85,480,425	\$ 83,418	\$ 119,989,315	\$ 23,997,863
Local Revenue	\$ 23,929,452	\$ 23,352	\$ 33,589,895	\$ 6,717,979
Proprietors Income + Business-to-Businesses	\$ 644,105,920	\$ 628,564	\$ 904,134,814	\$ 180,826,963

Source: Davidson-Peterson Associates (2008), adjusted using trend data from Tourism Economics (2016).

To bring the estimates of direct visitor spending closer to the present, we turn to a recent study by Tourism Economics (2016) that tracked statewide visitor spending from 2009 through 2015. The average annual growth rate in that spending was 5.0% (range: 3.1% to 7.8%). We applied that growth rate to the Arrowhead expenditure estimate for 2008 and, applying each year's statewide growth rate,⁶ we estimate that visitor spending in the Arrowhead region reached \$1.44 billion by 2015 (in 2016 dollars) (Table 1). That 2015 spending would have supported:

- 22,448 direct jobs
- \$380.7 million in residents' income
- \$153.6 million in state (\$120.0 million) and local (\$33.6 million) taxes
- \$904.1 million in proprietors' income and business-to-business sales.

Finally, with our survey of business owners as a guide, we consider what the impact of a 20% reduction in visitor spending would mean for the Arrowhead region. Losing that \$287.7 million in spending would cost the region 4,490 jobs (about 4.9% of total private employment in the region), \$76.1 million in workers' income, \$30.7 million in state and local taxes, and \$180.8 million in proprietor's income and business-to-business sales (Table 1). That loss would occur each year that the presence and operation of sulfide-ore copper mining keeps 20% of visitors away.

Because Davidson-Peterson collected and reported data from visitors based on where they stayed (travelers were surveyed on-site during their visit), it is likely that their initial spending estimates reflect spending throughout Minnesota even though that spending is ascribed to the county where the traveler was staying when surveyed. Thus, a traveler who lodges in Ely before jumping off for a canoe trip in the Boundary Waters Canoe Area Wilderness would have been asked about all their spending to get there, what they planned to spend on provision, guiding services, what was paid for a meal at a restaurant on the way to Ely, and the cost of gas for a rental car. The entire expense of the trip would have been tagged as being due to the time in St. Louis County. By the same token, if our traveler had been surveyed during a one-night stay in a Minneapolis hotel before flying home, all those expenses would have been ascribed to Hennepin County.

This feature of the underlying data means that some travelers' expenditures are misplaced, but we assume that for any given county, the misplacement of expenditures goes both ways: some dollars are ascribed to the county that should not be, and other dollars that were spent in the county were ascribed to another county. We assume that in aggregate, these errors cancel each other out. We therefore have not attempted to estimate the portion of expenditures occurring in the Twin Cities or elsewhere in Minnesota that are, in reality, due to the attraction of the Boundary Waters.

Losses to the Broader Economy

Amenity-rich communities around the country know that a high quality of life, including a clean environment and access to high-quality outdoor recreational and scenic resources, are the natural capital that supports much of their economies. Visitation and visitor spending are certainly part of that, but the effect extends to all sectors of the economy. This is especially true for "footloose industries" or operations that do not need to be located near either input supplies (e.g., commodity raw materials),

⁶ For 2008-2009, for which calculation of a statewide annual growth rate was not possible, we used the average of the growth rates for 2009 through 2015.

or output markets. With today's global economy, and advanced communication and transportation networks, the list of industries that are footloose grows by the year.

For example, Niemi and Whitelaw (1999) state: "natural-resource amenities exert an influence on the location, structure, and rate of economic growth.... This influence occurs through the so-called people-first-then-jobs mechanism, in which households move to (or stay in) an area because they want to live there, thereby triggering the development of businesses seeking to take advantage of the households' labor supply and consumptive demand" (p. 54). They note that decisions affecting the supply of amenities "have ripple effects throughout local and regional economies" (p. 54). Similarly, Johnson and Rasker (1995) found that quality of life is important to business owners deciding where to locate a new facility or enterprise and whether to stay in a location already chosen. This is not surprising. Business owners value safety, scenery, recreational opportunities, and quality of life factors as much as residents, vacationers, and retirees.

As we have already seen (Ronnader, Wentz, and Hove, 2014), environmental quality, recreational opportunities and other quality of life factors are the most important reasons Arrowhead residents give for living in and owning property in the region.

To the extent that sulfide-ore copper mining would diminish the physical qualities of the natural environment in the Arrowhead region, or even to the extent mining would alter the perception of those qualities--that is if mining damaged the region's "brand" built on the quality of the environment--one would expect that fewer people will want to relocate to the region to retire, to take a job, or to start up a new business. The "four townships" study and our business survey gives some information about the potential magnitude of that effect, and we use that information to sketch a set of simple scenarios for what the impact on jobs and income might be. We do note up front, however, that further research to determine more precisely how mining might affect location decisions by current and potential residents would be desirable as part of the review of mining in the Boundary Waters watershed.

Ronnader, Wentz, and Hove (2014) found that 23% of property owners said that concerns over mining would cause them to leave, or at least want to leave, the region. Similarly, our survey of business owners indicates that sulfide-ore copper mining could depress their businesses' prospects by 20%, on average. One scenario, therefore, would be that there is a 20% drop in economic activity in the region.

As a general indicator of economic activity, we begin with total employment and total personal income. Both include proprietors' (the self-employed) additions to the economy. Total personal income also reflects the contribution of retirees in that it includes income from investments and transfer payments like Social Security and Medicare that retirees would spend in the region.

To avoid double counting, we then net out the contributions to jobs and income from visitor spending. We also net out those jobs and income in industries least likely to be footloose, namely farming, forestry, and mining itself.

We also consider two less drastic scenarios. In a second scenario, we consider the effect of a 10% drop in jobs and income, and in the third, we consider no actual drop, but merely a cessation of the growth the region has seen since the beginning of recovery from the mining bust of the early 1980s. Since 1983, the Arrowhead region has seen average annual job growth of 4.4% and average annual growth in total personal income of 5.0%.

The range of impacts from these scenarios range from a loss of 5,066 jobs and \$402.4 million in personal income (per year) if growth simply flatlines, to a loss of 22,791 jobs and \$1.6 billion in annual income if 20% of the economy were to, essentially, move away. See Table 2 for details.

Table 2: Overall Economic Decline in Three Scenarios for the Impact of Sulfide-Ore Copper Mining

	Jobs	Income (000s of 2016\$)
Total Jobs or Personal Income	134,402	\$ 9,400,027
Less Travel-Related	15,787	\$ 903,570
Less Commodity-Related	4,660	\$ 464,755
Potentially Amenity-related	113,955	\$ 8,031,702
Mining Impact Scenarios		
20% reduction	-22,791	-\$ 1,606,340
10% reduction	-11,396	-\$ 803,170
No Growth*	-5,066	-\$ 402,369
* Loss of 4.5% job growth, and loss of 5.0% income growth Sources: Headwaters Economics: Economic Profile System- https://headwaterseconomics.org/ ; SocioEconomic Measures: Underlying Data Sources: U.S. Department of Commerce. 2016. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C. Tables CA30, CA05N, and CA25N; Ronnader, Wentz, and Hove (2014); and tourism data cited above.		

Lost Property Value

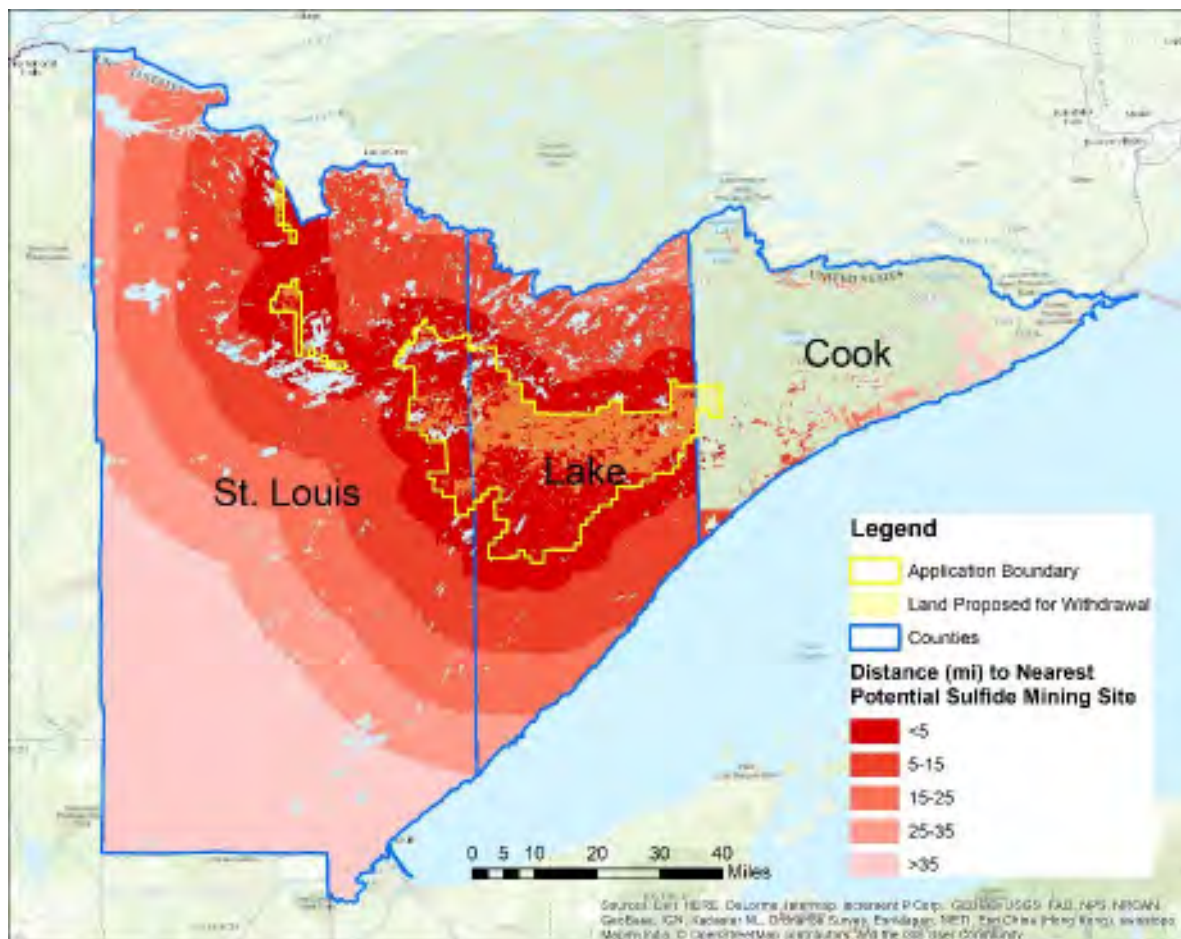
There is a ring of truth to the old saw that “location, location, and location” are the three things that matter most to the value of real estate. Namely, the location of a property relative to various amenities and disamenities can have a significant impact on buyers’ willingness to pay for the property. Natural amenities, like clear lakes (Schuetz, Boyle, and Bouchard, 2001), pastoral scenery (Fleischer and Tsur 2009), and wilderness and other protected areas (Phillips 2000; Beaton 1991) add value to properties over and above other attributes (improvements, road frontage, school quality, tax rates, etc.) that also influence land prices.

The same is true of disamenities: there are negative impacts on land value from various types of local nuisances that impose noise, light, air, and water pollution, life safety risks, and lesser human health effects risks on nearby residents and even entire communities that “gain” a new industry with such impacts (Sun, 2013; Bolton and Sick, 1999; Boxall et al., 2005; Williamson, Thurston, and Heberling, 2008). Erickcek (2006), Sun (2013), and Kim and Harris (1996) studied gravel, gold, and copper mines, respectively, and found that, in general, the closer a property is to the mine site, the lower is its property value. This negative effect typically decays with distance--that is, moving another mile closer to the mine produces a bigger drop in property value if you are already closer to the mine. In Sun’s study, which covered a time span that included both the opening and the closing of the mine, also found a large negative impact on every property in the county that occurred when the mine opened.

For this study, we apply the parameters from Kim and Harris (1996), who examined property values near a copper mine in Green Valley Arizona. To take the decay in the effect of the mine into account, they used a nonlinear transformation of distance to the mine in place of the simple distance. (The transformation is $X=1.05-(0.9947)^D$, where “D” is the distance in miles from the subject properties to the mine.) As is typical in these studies and for statistical reasons, the authors used a “log-log” version of the model in which the natural logarithm of the price of property is regressed against the natural log of the transformed distance and other variables. The coefficient on the distance function (0.2872 in their case) then represents the change, in percentage terms, of a property “moving” one percent farther away from the mine, when other things are held equal.

We do not have full information about all attributes of the properties in the Arrowhead region, but by computing distances from each property to potential sulfide-ore copper mining sites and applying the coefficient on the transformed distance, we can derive an estimate of the impact of new mining activity on properties in the Arrowhead. We conducted the analysis based on the distance from each property to the nearest Forest Service fee-owned parcel within the “Application Boundary”. In other words, we computed the distance from each private parcel to the nearest point that could, if the 20-year withdrawal is not approved, be subject to sulfide-ore copper mining. (See Figure 16).

Figure 16: Parcel Distance to Areas Potentially Open to Sulfide-Ore Copper Mining



Sources: St. Louis, Lake and Cook Counties’ respective GIS and Tax Offices, USDA Forest Service, ESRI.

We obtained parcel maps and information on the value of each parcel directly from each of the three Arrowhead counties. Due to the per-parcel fee charged for Cook County data, we obtained data only for privately owned parcels. Because publicly owned parcels do not have listed values and are not subject to sale, they should suffer no loss in market value due to mining. This gap in the data does not affect the analysis, but it is something to keep in mind when viewing the map in Figure 16. Publicly owned parcels in Lake and St. Louis Counties also have no market value, but the data sets for those counties did include all parcel boundaries.

Using the “NN Join” plugin in Quantum GIS, we calculated the distance from each parcel to the nearest polygon representing an area potentially open to sulfide-ore copper mining. The greatest potential separation is 77.9 miles to a parcel in northwest St. Louis County.

After computing these distances, and we then applied the statistical results from Kim and Harris (1996) to estimate the percentage change in property value (which is how one interprets those results when the log-log functional form is used). Parcels closest to mining sites would lose 5.74% of their value, and those farthest away would lose as little as 0.66%. By applying these percentages to each of the more than 243,000 parcels, per-parcel losses and aggregate property value losses are obtained.

Based on these procedures, we estimate that some \$508.9 million in property value would be lost if sulfide-ore copper mining were to occur on all of the areas proposed for withdrawal from the federal mining program. (See Table 3.)

Table 3. Estimated Property Value Impacts of Sulfide-Ore Copper Mining, 2016.

	Number of parcels	Total Property Value (2016\$)	Property Value Lost (2016\$)
Cook County	8,460	\$ 1,651,043,600	\$ 30,722,257
Lake County	45,303	\$ 3,378,180,900	\$ 115,161,294
St. Louis County	182,143	\$ 20,760,741,439	\$ 363,031,214
Total	235,906	\$ 25,789,965,939	\$ 508,914,765

As with other costs discussed in this report, we believe the actual impacts of sulfide-ore copper mining on land value would be much higher than those presented in Table 3. There are two primary reasons actual effects would be higher.

First, the study from which we used parameter estimates was focused on air quality impacts of copper mining that, while acute for properties closest to the mine, could decay more rapidly as distance from the mine increases. For other facets of the value of land in the Arrowhead region, such a decay may not be as pronounced, or it may not occur at all. For example, one may own (or consider buying) property in the Arrowhead region so that one can be relatively close to high quality recreational resources or to places with high levels of wilderness character.

The ability to get to high quality recreational resources and relatively pristine natural areas is reflected in buyers’ willingness to pay for properties near such resources and is capitalized into the price of properties throughout the Arrowhead region and, arguably, throughout the entire state of Minnesota. When noise, light, dust, and water pollution due to sulfide-ore copper mining diminishes the quality of the experience of areas near mining sites--or even if it diminishes only the *perception* of the quality of the experience--people will likely be willing to pay less for first or second homes purchased with an eye

toward be near the Boundary Waters. In other words, impacts on property values may remain strong over much greater distances than our conservative assumptions and these initial estimates suggest.

The other reason these property value effects are low is that they are merely “partial equilibrium” effects. They capture (at least some of) the direct nuisance effect of mining on property values, but they do not capture the second-round effects of a loss of vitality in the economy due to reductions in visitor spending and lost overall economic vitality. If population, jobs, and income decrease due to the advent of sulfide-ore copper mining, as described in the preceding sections, there will be fewer people with fewer dollars and with less optimism for a future, sustainable economy. Demand for housing will suffer along with the rest of the economy, and housing prices can be expected to fall. That may be good news for someone moving to the Arrowhead to take one of the comparative handful of new mining jobs, but for property owners already invested in the region, it will mean a loss of asset value and personal wealth.

SUMMARY AND RECOMMENDATIONS TO THE FOREST SERVICE

The Arrowhead Economy benefits from unique scenic, recreational, and environmental amenities. The clean water, peace and quiet, canoeing and hiking trails of the Boundary Waters Canoe Area Wilderness and the surrounding Superior National Forest, Voyageurs National Park, and the North Shore of Lake Superior are well-known international attractions for visitors and for new residents. In order to protect these outstanding resources “from the potential adverse environmental impacts arising from exploration and development [of mineral resources on federal lands]”, the Forest Service has proposed withdrawing 234,328 acres of federally owned land in the Rainy River watershed from the federal mining program (82 FR 4283).

The Forest Service is now scoping its Environmental Impact Analysis, which under the National Environmental Policy Act, must consider the economic effects of the proposed action alongside ecological, aesthetic, historical, social, and health effects (40 CFR 1508.8). The salient economic effects of this action would include, as a benefit to society, the avoidance of costs associated with actual and potential sulfide-ore copper mining that, absent the proposed action, could proceed in the watershed of the Boundary Waters. As the estimates described here demonstrate, even a fraction of those costs significant. The small subset of potential economic effects of sulfide-ore copper mining considered in this report include

- A decline in spending as potential visitors choose alternative destinations with high quality scenic and recreational amenities undiminished by nearby mining activity. We estimate an annual loss of \$288 million in spending that would otherwise support 4,490 local jobs, \$76 million in residents’ income, \$31 million in state and local taxes, and \$181 million in proprietor’s income and business-to-business transactions
- 5,066 to 22,791 lost jobs, and between \$402 million and \$1.6 billion in lost annual income in the rest of the economy if sulfide-ore copper mining suppresses or reverses growth in the amenity-based economy that has been the backbone of the region’s recovery since the early 1980s
- \$509 million in lost property value. This is a one-time drop in asset value that will spawn annual reductions in local property tax revenue throughout the Arrowhead region.

As the caveats given along with our methods and estimates suggest, these numeric estimates should be considered conservative first approximations of the true and complete costs of sulfide-ore copper mining in the watershed of the Boundary Waters and, by the same token, of the positive economic effects of the proposed action). We would therefore recommend the Forest Service devote sufficient time and resources to fully explore all of the economic effects of the proposed action. Specifically, the agency should include the following in its Environmental Impact Assessment:

1. Conduct a systematic survey of business owners and managers to estimate the effect of potential sulfide-ore copper mining on the outlook for Minnesota, and especially Arrowhead Region, businesses in all sectors.
2. Complete a thorough, statistically valid survey of residents, visitors, vacation and second homeowners, and other stakeholders to determine the sensitivity of individual's and other stakeholders' decisions about whether to vacation, retire, locate, or stay in the Arrowhead region under alternative scenarios involving the presence and extent of sulfide-ore copper mining in the proposed withdrawal area.
3. Commission or perform a hedonic price study of residential, commercial, and other property values in areas where similar mining operations have occurred. The scope of effects in such a study should go beyond direct air, water, and visual effect, to include effects on "wilderness character". Insights and parameters from such a study should then be used to estimate land value effects near the proposed withdrawal area.
4. Examine the extent to which forecasted mining employment in both lower- and higher-wage positions will be available to, and filled by, current Arrowhead residents. That is, how will the potential benefits of sulfide-ore copper mining be distributed among existing residents and workers brought in from elsewhere.
5. Evaluate the avoided impact on all ecosystem services that would occur if the proposed withdrawal is not implemented. Ecosystem services affected would include:
 - a. timber (a renewable raw material) from forestland is lost to mine-related infrastructure, including roads, buildings, tailings piles and others;
 - b. food, including the nutritional value of fish and game species and edible wild plants no longer able to use or thrive in terrestrial and aquatic habitat affected by mining;
 - c. water for drinking;
 - d. recreational opportunities, including as valued by impacts (expenditures, jobs, income, etc., as considered in this report) as well as by benefits (the value to the recreational user over and above the out-of-pocket cost of the recreational experience). Loss of benefit if the proposed withdrawal is not implemented would afflict would-be visitors who stay away due to the new type of mining in the Boundary Waters watershed, as well as those visitors who do come but find their experience diminished by sulfide-ore copper mining; and
 - e. other ecosystem benefits described, for example by Balmford et al. (2010).
6. Estimate impacts on passive-use value. The Boundary Waters belong to and are loved by people throughout our Nation and the world who would want to know that its resources remain unimpaired and who would want to ensure that they or their descendants have the option of future use of the Boundary Waters without the impacts of sulfide-ore copper mining.

Above all, the Forest Service's economic analyses to be included in the Environmental Impact Statement should be grounded in a 21st-century understanding of economics and the reality that there is more to the foundation of the Arrowhead Region's economy than what can be dug up and shipped away.

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APPENDIX A: BUSINESS OUTLOOK SURVEY

Using Survey Monkey, we solicited input from 140 members of the “Boundary Waters Business Coalition”. We received 31 responses (a 22% response rate) to the following 10-question survey.

1. Which of the following best describes the industry that your business (or non-profit or public agency) is a part of?

[Options included all two-digit NAICS industries, plus some three-digit industries where the distinctions between, say, “Retail, clothing and accessories” and “Retail, food & beverages” could have been helpful.]

Industries describing the respondents businesses were:

Agriculture, forestry, fishing and hunting	(n=2)
Arts and entertainment (galleries, theaters, etc.)	(n=1)
Construction	(n=1)
Information (publishing, motion pictures, internet hosting and content)	(n=1)
Manufacturing, apparel	(n=1)
Manufacturing, Other	(n=1)
Manufacturing, wood Products	(n=1)
Other services	(n=1)
Professional, scientific, and technical services (law, accounting, etc. not health)	(n=1)
Recreation, guiding and outfitting	(n=7)
Retail, clothing and accessories	(n=1)
Retail, food & beverages	(n=2)
Retail, sporting goods (which may include clothing)	(n=7)
Other or Combination	(n=4)

2. Which of the following best describes your role in the business/organization/agency?

Owner/Co-owner	(n=26)
Senior Manager	(n=2)
Employee	(n=3)

3. How many FULL-TIME employees did the company have in 2016? (Include yourself if applicable.) Please count only those who worked full-time and year-round.

1-4	(n=19)
5-9	(n=3)
10-19	(n=6)
1,000 or more	(n=1)
No answer	(n=2)

4. How many PART-TIME employees did you have in 2016? (Include yourself if applicable.) Please count employees who worked less than full time AND those who worked any number of hours per week, but for less than the full year.

1-4	(n=10)
5-9	(n=7)
10-19	(n=6)
20-49	(n=2)
50-99	(n=1)

1,000 or more	(n=1)
No answer	(n=4)

5. Gross Sales: What was the level of your gross sales (or if an organization or agency, what was your budget) in 2016? Remember, your answers are confidential and will be used only as part of aggregate measures (averages, etc.).

Less than \$100,000	(n=6)
\$100,000 - \$500,000	(n=12)
\$500,000 - \$1 million	(n=5)
\$1 - \$5 million	(n=6)
More than \$100 million	(n=1)
No answer	(n=1)

6. How would you rate your awareness of/knowledge about the issue of sulfide-ore copper mining in the watershed of the Boundary Waters, and your level of engagement (talking about, writing letters, reading up on, etc.) related to the issue?

Average of 8 (range 5-10, n=31) on a 0-10 slider, where

0 corresponded to "I have not heard much or anything about it."

5 corresponded to "I am pretty well informed about the issue, but I am not actively following or taking any action related to it.", and

10 corresponded to "I know a lot about the issue, and I am regularly engaged in conversations and actions related to it."

7. Scenario 1: If sulfide-ore mining is NOT APPROVED and the economy of the Arrowhead region (St. Louis, Lake and Cook Counties) continues to develop as it has over the past 30 years, what are your expectations for how YOUR OWN business/organization/agency might change over the next 5-10 years?

Average of 7 (range 5-10, n=31) on a 0-10 slider, where

0 corresponded to "We expect to shut-down/ go out of business."

5 corresponded to "No change: we're about the right size.", and

10 corresponded to "We plan to expand by 100% (double in size) or more."

8. Scenario 2: If sulfide-ore copper mining WERE TO BE APPROVED in the watershed of the Boundary Waters, how would you expect YOUR OWN business/organization/agency to change over the next 5-10 years?

Average 4 (range 2-10, n=31) on a 0-10 slider, where

0 corresponded to "We expect to shut-down/ go out of business."

5 corresponded to "No change: we're about the right size.", and

10 corresponded to "We plan to expand by 100% (double in size) or more."

9. For the second scenario please describe HOW you would expect sulfide-ore mining in the watershed of the Boundary Waters to affect your outlook and your plans for your business or organization.
10. Please use this space for anything else you would like to say about the current and future business climate, economic development, or the prospects for your own business as it relates to sulfide-ore copper mining proposed for the watershed of the Boundary Waters.

A Review of “The economic impact of ferrous and non-ferrous mining on the State of Minnesota and the Arrowhead Region”¹

Evan Hjerpe, Ph.D.[†] and Spencer Phillips, Ph.D.[‡]

December 30, 2013

Brief Summary: Regional economic impact analyses can be helpful in illustrating potential changes in output, income, and employment that might result from new development. Economic impact analysis (EIA) is, however, subject to stringent methods that must be adhered to in order to provide credible estimates of impacts. Additionally, EIA is based on an underlying set of restrictive technical assumptions that may apply only in rare instances. Thus, great care must be taken in conducting and using the results of economic analysis if it is to have any value at all. The proliferation of turn-key economic impact models, such as IMPLAN, has made it extremely easy to produce estimates of economic impacts by non-economists or economists with little training in this area. Impacts can be generated with little consideration for the underlying methods and technical assumptions. This has resulted in a wide range of quality in economic impact analyses.

After examining “The economic impact of ferrous and non-ferrous mining on the State of Minnesota and the Arrowhead Region, including Douglas County, Wisconsin,” (hereafter “the UMD report”) we conclude that the University of Minnesota, Duluth’s economic impact analysis falls squarely at the “low-quality” end of the spectrum. In brief (and as detailed below), the reasons for this conclusion include the following:

- The authors of the UMD report failed to adhere to a number of the most critical EIA methods. Multiple violations of standard EIA methodology undermine all generated IMPLAN results.
- The underlying technical assumptions of input-output modeling, the core tenet of IMPLAN, lead to an unrealistic picture of the regional economy, because they inflate induced effects and multiplier effects. As such, researchers generally take a deliberately conservative approach and/or perform sensitivity analysis. The UMD report incorporates neither.
- The authors of the UMD report provide no comparison of potential mining multiplier effects to multipliers for other industries within the regional economy. Without comparison, the reader has no context with which to judge the impacts.
- The authors do not acknowledge the limited role and application that EIA results have in the overall environmental assessment of mining impacts. Apart from a brief note in Appendix B that “a detailed cost-benefit analysis is beyond the scope of this report,” the UMD study does

¹ Skurla, James A. et al., *The Economic Impact of Ferrous and Non-Ferrous Mining on the State of Minnesota and the Arrowhead Region, Including Douglas County, Wisconsin* (University of Minnesota, Duluth: Labovitz School of Business and Economics, November 2012), <http://www.d.umn.edu/lbsbe/bber.php>.

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nothing to place the modeled (short-term) economic impacts in the context of what are reported elsewhere to be significant, long- and short-term negative environmental, economic and fiscal impacts of non-ferrous mining in Northeast Minnesota.²

1. Introduction

New, non-ferrous mines are being proposed in northeastern Minnesota, but need to undergo an environmental planning process to help determine if the new mines are in the public interest of Minnesotans. The primary component of determining public interest is assessing the overall environmental impacts of proposed projects to determine if the public benefits outweigh the public costs. Part of this process has also typically included an assessment of potential economic impacts that might be generated by the proposed mining. A recent study, “Economic Impacts of Ferrous and Non-Ferrous Mining on the State of Minnesota and the Arrowhead Region, and Douglas County, Wisconsin,” was conducted by The Labovitz School of Business and Economics at the University of Minnesota Duluth (hereafter, “UMD report”). In this paper, we review UMD’s economic impact analysis, so as to provide an objective perspective on the associated economic impacts of proposed mining expansion, with particular attention to new non-ferrous mining. Because proposed non-ferrous (sulfide) mining is new to the region and has the greatest environmental impact, we review the report with an eye on the implications for non-ferrous mining.

The UMD report suffers from multiple technical and methodological flaws and does not address any associated costs of non-ferrous mining. These flaws include: inappropriate study area delineation, a lack of rigor in data collection, and inappropriate inclusion of past economic activities related to existing mining production. Additional problems, and technical errors, were also found throughout the report that led to consistently inflated economic impacts. The presented economic impacts are therefore not credible estimates and require an entirely new analysis to correct these fatal flaws.

2. Economic Impact Analysis (EIA) and Environmental Planning

To provide greater understanding of the role of the UMD report, it is helpful to first frame the scope of EIA in terms of its value in determining overall public costs and benefits. In the broad picture of net public interest, EIA is narrowly focused on short-term changes in regional economic indicators. As such, EIA does not shed light on any associated costs to society that might result from the proposed development (e.g., environmental impacts, damages to other industries, or long-term viability of the industry or the region). Furthermore, economic impacts, even if positive, are rarely considered as economic benefits for the regional economy.³ This is because regional economies are dynamic, but gravitate towards equilibrium in terms of economic indicators. That is, losses in one sector of the economy are generally offset by gains in other sectors; and gains in one sector are generally offset by

² Marcotty, Josephine, “Iron Range Mine Could Pollute Water for up to 500 Years,” accessed December 3, 2013, <http://www.startribune.com/local/226548091.html>; Dunbar, Elizabeth, “State’s Top Elected Officials Approve Mineral Leases, with Reservations,” *MPR News*, accessed November 25, 2013, <http://minnesota.publicradio.org/display/web/2013/10/25/elected-officials-vote-on-mineral-leases>.

³ Consumer surplus is the appropriate measure for economic benefits.

losses in others, despite the tendency for regional economies to attain overall growth or restriction in the long run.⁴

Thus, the results of economic impact studies provide only a portion of the overall economic effects associated with proposed development, for a very limited amount of time, and virtually none of the overall societal costs and benefits over time. This is important to consider when exploring regional economic development strategies.

Another consideration for the scope of economic impacts is that most are presented in isolation. While generated multipliers and impacts may appear large or small, the public and decision-makers have no context for the results if they are not compared to multipliers and impacts from other industries for a similar regional economy. What do these numbers mean? Depending on geographic, demographic, and other variables, regional economies and individual entrepreneurs have choices in the form of economic development they would like to pursue. Without a comparison to the impacts and multipliers associated with other types of industrial development in a particular region, the public and decision-makers do not have a proper context for framing results.

3. Disregard for Critical Economic Impact Analysis (EIA) Methods

We present the most critical EIA methods in detail below to provide the reader with their importance in determining all the subsequent results and economic impacts provided by models such as IMPLAN. Failure to adhere to these methods produces unreliable and inaccurate estimates of economic impacts, often leading to double, triple, and quadruple counting of unique economic impacts of income, employment, or industry purchases.

3.1 Defining initial changes in final demand

The driver of economic impact analysis is the *change in final demand* (via output, value-added, or employment) in the defined region that will be spurred by a new development. This change in final demand, or “shock” to the regional economy, is estimated by the researcher based on surveys of businesses and individuals, or in the case of the UMD report, getting input from mining companies and other groups to ascertain “employment estimates, local purchases, and operations dollar value of sales or output production (p. 3).” The change in final demand is entered into IMPLAN software and applied to the predictive I-O model for the particular region being studied. Once changes in final demand are entered into IMPLAN for the affected industry sectors, the software provides the *direct effect* to the region (subsequent analysis options allow for estimating *indirect and induced effects*).

All changes in final demand result in direct effects, but based on regional purchasing coefficients (RPCs) and location quotients as defined by the size and structure of the regional economy, IMPLAN software categorizes these direct effects by industry sector, domestic trade, and foreign trade. That is, direct effects are the initial estimate of how much of the regional final demand changes impact regional

⁴ These economic trends are perhaps easiest to understand from the individual laborer perspective. Regional economies typically have a limited labor supply. When an individual loses their job, they typically seek and find work at another company, as opposed to staying unemployed and representing a permanent loss to the economy.

industry sectors, how much leaves the defined region as domestic trade, and how much leaves the country as foreign trade.

Critically, data collection for changes in final demand is concerned only with economic activity that occurs in the defined study area. For example, if a mining company owns a mine in one part of the state, has state headquarters in another part of the state, and has international headquarters outside of the U.S., different changes in final demand will occur in all three areas based on new mineral sales. The location and impact of final demand changes based on mineral sales is different for each particular region. Given this, the proper delineation of the study area for regional economic impact analysis, and capturing final demand changes that occur within that region, are critical first steps in determining accurate direct effects and subsequent multiplier effects.

Multipliers represent the amount and number of times economic activity (e.g., output, value added, or employment) re-circulates within the defined study area. Specifically, multipliers are the ratio of total effects (direct + indirect + induced) to direct effects. All economic activity that is not captured by the local economy due to imports and purchases elsewhere is considered leakage. *The size of the defined study is a major determinant of the resulting multiplier effect, with larger study areas capturing more of the economic activity.*

Researchers have illustrated that study areas for regional EIAs should be restricted to the region most affected, not only in terms of economic impacts, but also in terms of costs incurred.⁵ The reasons for this are twofold. First, increasing the study area for localized economic development projects (such as for a few counties) beyond its primary economic influence (e.g., to the state-level) results in inflated multipliers and impacts. Secondly, and perhaps more importantly, an EIA should compare local economic impacts to local costs of such development including the need for greater public services and costs associated with environmental degradation.

As such, changes in final demand are strictly the purchases, sales, and employment that will occur within the study area. On p. 6, the UMD report correctly defines direct effects as *“Initial spending in the study area resulting from the project.”* On the same page, the UMD report also correctly defines value added and output in terms of *“contribution to the local economy”* and *“the value of local production.”* But, throughout the UMD report, two dramatically different study areas are used (the Arrowhead Region and the State of Minnesota), yet the majority of direct effects remain the same for both. This indicates that only one set of final demand changes were used for both study areas. This is a fatal flaw that undermines the credibility of the entire report.

- The authors of the UMD report utilize and present results for two different study areas: 1) the Arrowhead Region of Northeast Minnesota, which includes seven adjacent Minnesota counties and one adjacent Wisconsin county; and 2) the entire state of Minnesota, which includes 87 counties. The proposed mining expansion will all occur in the Arrowhead Region, making this the more appropriate study area. The only reason we can see for also utilizing an additional study

⁵ Hjerpe, E.E. and Y. Kim. 2007. Regional economic impacts of Grand Canyon river runners. *Journal of Environmental Management* 85(1): 137-149.

area of the entire state of Minnesota is to boost reported economic impacts. Indeed the first and primary comprehensive Table provided in the executive summary shows only the inflated impacts resulting in the entire state (p. viii). Utilizing two separate study areas is inappropriate and reflects a poor understanding of economic impact analysis. *If using multiple study areas, each study area must have its own survey (or data collection) of changes in final demand.*

- For these different study areas, most of the reported direct effects are identical. (Compare Tables 4 and 5 (p. 11); Tables 8 and 11 and Tables 9 and 12 (pages 14-15); Tables 18 and 19 (p. 20); Tables 22 and 25 (pp. 22-23); Tables 23 and 26 (pp. 23-24); Tables 33 and 35 (pp. 28-29), and Tables 34 and 36 (pp. 28 and 29). This illustrates that the researchers did not collect economic data specific to each defined study area, but rather utilized one set of final demand changes for both study areas. This is problematic for a number of reasons. First, Douglas County is in Wisconsin, and changes in final demand (and resulting direct effects) for construction, operation and output sales that occur in Wisconsin should not be counted in Minnesota. So even if 100 percent of the direct spending associated with the proposed new mining were to occur in the smaller study region, at least some of that effect would have to accrue to Minnesota's neighbor to the east.

Second, it is extremely unlikely that 100 percent of the direct spending would occur in the Arrowhead region in the first place. At least some of the increase in employment required to support the new and expanded mining would occur in the company's down-state and/or out-of-state / out-of-country offices (i.e., PolyMet state headquarters in St. Paul and international headquarters in Toronto). Wages and salaries earned by managers in the Twin Cities should not be confused with (or counted the same as) wages and salaries earned by mine workers in the Arrowhead region.

Third, it is likely that the sale of ore itself would be transacted in places far from the mine, and large portions of those sale proceeds (e.g., profits) would be part of the direct effect in those distant places, not in the Arrowhead Region. As is often the case with multinational mining companies, only the value-added portions of mineral sales would accrue as economic impacts in the Arrowhead Region.

Without seeing the precise assumptions and numbers that went into the estimation of the initial changes in final demand, it is not possible to say how much smaller the direct effect in the Arrowhead region should be. One can be certain, however, that those effects would be different, and smaller in the region than in Minnesota as a whole.

Interestingly, there are a couple exceptions in the presented Non-Ferrous Mining direct effects (Tables 22 and 25, and Tables 23 and 26) where only the value-added components are actually slightly different and are carried over to the summary tables in the combined totals at the end of the report. However, the value-added direct effects in these tables are actually higher in the smaller, Region Operations tables. We presume these are typos, as it suggests that value-added

impacts that occur in seven Minnesota counties somehow got lost on their way to the State of Minnesota. (The only way this would make sense is if the effects are so much larger in Douglas County, Wisconsin that they overwhelm the difference between Minnesota-wide effects and those occurring in the Minnesota portion of the Arrowhead region. But of course if this is true, then it further calls into question the estimates of direct value-added effects that are identical for the entire Arrowhead region and the entire State of Minnesota. (See, for example, Tables 9 and 11.))

- There is very little detail presented in the UMD report concerning their data collection and their construction of initial changes in final demand, yet this critically determines the direct effects and additional indirect and induced effects. The reader is only told that mining companies and other mining associated groups provided input to the authors to ascertain “employment estimates, local purchases, and operations dollar value of sales or output production (p. 3).” Accuracy and consistency in data collection is the first fundamental step in sound science. How were data collected? Did the author’s provide respondents with a written survey? In-person interviews? What regional economic study area was used? This information should be noted in the text and surveys and data collection instruments should be provided in an appendix.
- Many of the estimated jobs may be filled by transient workers, who will earn wages in the area and spend them elsewhere. It is not clear if this was taken into consideration for the initial estimates of changes in final demand. If not, employment effects will be overestimated for the regional economy.

3.2 Defining economic impacts

EIA, and its technical assumptions, are predicated on forecasting the impacts of *new* changes, or a “shock,” in final demand for a regional economy, most often from a proposed policy change or development plan. Economic impact analysis is defined in the IMPLAN Analysis Guide⁶ as:

“An assessment of change in overall economic activity as a result of *some change* in one or several economic activities [emphasis added].”

Despite this, the UMD report includes all *on-going* ferrous and non-ferrous mining operations in the impact study, combined with estimates of new construction and operation. The first summary table in the Executive Summary (p. viii), and likely the most important take home message from the report, claims that the total economic impacts are a “...Value Added total of almost \$5 billion, and Output of almost \$7.8 billion, and an Employment total of more than 27,300 (p. viii).”

Existing operations are supposed to be used to understand the current economic relationships between industry sectors that will be used to estimate potential economic impacts from the “shock” of new final demand changes in that industry. *These impacts have already been absorbed by the regional economy and should therefore not be counted among the impact of the new changes in the economy.* Inclusion of

⁶ IMPLAN Professional Analysis Guide. 1999. Technical Report. Minnesota IMPLAN Group, Inc.

existing operations indicates a lack of understanding economic impact analysis and grossly exaggerates impacts. In reality, such rapid mining expansion would come at the loss of existing mining industry due to increased cost of supply inputs and decreased market prices of final products from flooded local markets.⁷

4. Critiques of I-O Modeling and Implications for the UMD Report

There are numerous technical assumptions required for input-output (I-O) modeling, a core tool of economic impact analysis. I-O modeling is the balancing of all industrial sector sales and purchases, and exogenous sectors such as households,⁸ government, and foreign trade. That is, increases or decreases in one sector will yield a cascading effect on many other sectors that will ultimately balance out. The primary technical assumptions include linearity among production functions, fixed technical coefficients, homogenous sector output, and no supply constraints.⁹ The resulting implications of these assumptions yield a static regional economy, with no economies of scale, no technological advances, and an unlimited supply of resources and labor. In short, this is far from a realistic portrayal of any regional economy, but necessary for the mathematical balancing conducted within I-O models. These assumptions traditionally lead to inflated economic impacts. For example:

- Due to the unrealistic technical assumptions necessary for input-output modeling, all multipliers, and especially employment multipliers, are inflated and should be viewed with extreme caution. For example, the linear production functions lead to the presumption that businesses and households will spend and consume at the same rate. In reality, once a certain threshold in income is achieved, more saving and investing occurs (and often these savings are invested outside the region).
- Another example comes from the hypothetical economic assumption of fixed technical coefficients. Forecasting mining impacts in the year 2016 neglects improvements in technology. Labor-displacing technology is significant in the mining industry.
- The employment impacts in the UMD report are presented in terms of full and part-time jobs, not Full-Time Equivalents. Because of the seasonal and temporary nature of mining jobs, especially for all construction impacts, the reporting of employment impacts is suspect. The UMD report imparts no information of the typical percentages of seasonal and temporary workers in the mining industry. Without this context, the public and decision-makers are left wondering what the real impact will be. Likewise, the UMD report provides no comparison to potential employment impacts that might result from investments in other forms of economic

⁷ Stacking new impacts on top of on-going operations also illustrates the problems associated with unrealistic I-O modeling assumptions of linear production functions and unconstrained supply pools.

⁸ Households and other previously exogenous sectors have been “endogenized” in the structural accounting matrices used for most modern multiplier effects, such as in IMPLAN.

⁹ Miller, R.E. and P. Blair. 1985. Input-output analysis: foundations and extensions. New Jersey: Prentice-Hall, Inc.

development. How do these numbers compare to other industries that communities might want to pursue?

Given that the UMD report acknowledges how these assumptions can lead to overestimates, and given that information about the critical relationship between output and employment was provided by mining project managers without additional information taken from independent sources (p. 8), it would be reasonable to expect the UMD report to take a more conservative approach.

5. Tax impacts

The tax impacts from existing and proposed mining in Minnesota are presented in the UMD report in detail. At first glance, they appear impressive. Upon a closer examination, however, it becomes clear that the mining industry is afforded minimal taxation by the State of Minnesota.

- A calculation of overall taxes presented in the UMD report illustrate that the mining industry is afforded an *effective regional tax rate of less than one percent of calculated direct output*.

\$17.6 million in 2010 from Table 38, divided by \$1.85 billion of estimated direct output for both ferrous and non-ferrous 2010 baseline from Table 41 = 0.95%.

As direct output in the region is necessarily smaller than overall sales of final mining products, this effective regional tax rate is miniscule and represents major tax breaks provided to the mining industry. The more important question is how do these tax rates compare to other sectors in the economy? Given the normal regional rates of taxation on most industries (e.g. tourism), a comparison within the UMD report would provide substantial context for the public and decision-makers.

- No costs associated with mining are presented in the UMD report. Yet, we know from recent history that mining is a boom and bust industry, susceptible to volatile, global mineral pricing. We also know this type of development will require increased infrastructure, health, and emergency services that are needed with such rapid development. Additionally, ample public taxes will be needed in the future to pay for future rehabilitation and reclamation of degraded mining lands, as well as continual monitoring of water quality and active treatment for hundreds of years, at least.¹⁰ With such a miniscule effective tax rate for the mining industry, it seems prudent to question whether current annual taxes can keep up with the public service needs stemming from rapid development, much less provide for future clean-up costs.

But, the less than one percent effective regional tax rate per direct output is not the only exceptional characteristic of Minnesota mining taxation. A deeper look at the collected taxes

¹⁰ Karnowski, Steve, "New Environmental Review Due for PolyMet's Copper-Nickel Mine," *Associated Press*, accessed December 5, 2013, http://www.twincities.com/localnews/ci_24634015/minnesota-copper-nickel-mine-new-environmental-review.

shows that of 13 tax accounts, six are funneled back into minerals management (Table 38). While we do not know the exact distribution of each tax account,¹¹ the appearance is that a substantial portion of the taxes collected are reinvested back into the mining industry. This represents further tax breaks and kick-backs to the mining industry in Minnesota.

6. Other Problems with the UMD Report

The UMD report is deficient in many areas, leading to consistent inflation of actual economic impacts stemming from mining in the region. Other issues from the UMD report include:

- Table 1 and the discussion on Gross Regional Product (GRP) on page 4 are incorrectly presented, and very misleading. First, GRP is equivalent to a state's gross domestic product (GDP) and represents the market value of *final* goods and services. Including indirect and induced effects in GRP calculations (as noted beneath Table 1) is inaccurate and a poor use of multipliers and leads to substantial overestimates. In fact, intermediate inputs from other industries should be subtracted, not added (see BEA definition for state GDP).¹²

Secondly, the UMD report states that, "Note that the GRP for the State of Minnesota was \$281.1 billion. When compared to the State, mining GRP totals approximately 5.3% for 2010" (p. 4). At 5.3%, mining GRP for Minnesota in 2010 is presented as \$14.9 billion. However, when we looked at the source presented in Table 1 (BEA Regional data), we find that for 2010, mining as a whole represented only \$724 million of Minnesota GDP, or 0.3% of Minnesota GDP for that year (\$268.6 billion). It is unclear how the numbers in the UMD report were derived. *This is a major discrepancy and leads to vast inflation of mining's importance.*

- The comparisons to the tourism industry GRP in Table 1 are also misleading, as they vastly under-represent the industrial sectors that combine to make up the tourism industry. The tourism industry is comprised of portions of multiple industries, making it difficult to assign a GRP value. The notes for Table 1, state that tourism was estimated from two IMPLAN sectors, "amusements, gambling, and recreation," and "accommodation and food services." This, however, does not capture all tourism products. A number of researchers have illustrated that additional sectors combine to make up the tourism industry.¹³

¹¹ Some taxes may in fact be used to help clean up mine sites. But, the appearance is that a significant portion of mining taxes are spent on increasing mining development (e.g., funding university advocacy).

¹² The BEA defines gross domestic product by state as: "GDP by state is the value added in production by the labor and capital located in a state. GDP for a state is derived as the sum of the gross domestic product by state originating in all industries in a state. In concept, an industry's GDP by state, referred to as its "value added", is equivalent to its gross output (sales or receipts and other operating income, commodity taxes, and inventory change) *minus its intermediate inputs* (consumption of goods and services purchased from other U.S. industries or imported). Thus, GDP by state is the state counterpart of the nation's gross domestic product (GDP), BEA's featured measure of U.S. output." Italics ours.

¹³ For example, Marcouiller, D.W. and X. Xia (2008. Distribution of Income from Tourism-Sensitive Employment. *Tourism Economics*. 14(3): 545-565), include those sectors listed as well as portions from the Retail Trade and Passenger Transportation sectors.

- The UMD report gathered all necessary inputs from mining companies and mining-associated organizations and agencies. Given that the report was prepared for these same groups, we believe that a more objective approach would include input from other perspectives, particularly those of sectors (industries, households) likely to be harmed by non-ferrous mining in the study region.
- An earlier version of the 2012 UMD report was released by UMD in 2009. The 2009 version appears to suffer from the same methodological failures detailed above. However, one note of interest is the major decrease in economic impact for both existing and proposed non-ferrous mining expansions. The direct employment in the region for non-ferrous on-going operations decreases from 531 in baseline 2007 (in the 2009 UMD report, p. 30) to 175 in baseline 2010 (in the 2012 UMD report, p. 20), or a 67% decline. While we question the accuracy of all estimates in the reports, this is a precipitous decline if taken at face value¹⁴. It is also emblematic of the lack of accuracy in UMD's projected economic impacts. Instead of gaining more than 2,000 direct jobs in the region that were supposed to be operational by 2013 (as projected in the 2009 UMD report, p. 32), the non-ferrous industry has been losing jobs. This issue also highlights the inability of I-O models, such as IMPLAN, to account for changes in production functions and technical coefficients.

7. Conclusion

After thoroughly reviewing the UMD report, we conclude that the study is deficient in a number of areas and suffers from fundamental flaws. We also conclude that even if accurate economic impacts were presented for potential mining expansion, they should be viewed as a small component of the overall costs and benefits to society. The public interest should be most concerned with the long-term consequences of mining development, the costs incurred, and opportunities that will be lost.

Finally, communities in Northeastern Minnesota should be very cautious in pursuing a particular economic development strategy. "If some is good, then more is better," is not always applicable. To wit, economic diversification increases community resilience in times of recessions and when exposed to the "bust" cycle of an important industry sector. If mining is indeed already 30% of gross regional product in Northeastern Minnesota (p. 4), a virtual doubling of direct mining jobs will render the region utterly dependent on a known boom and bust industry, decreasing its overall economic diversification. This is not a wise economic development strategy.

¹⁴ We recognize a recession occurred during this time. However, baseline contribution of ferrous mining increased during this period.

**AN ANALYSIS OF A TWIN METALS PROJECT:
RISKS VS BENEFITS
BY MARSHALL HELMBERGER, THE TIMBERJAY
TOWER, MINNESOTA
FALL 2017**

Twin Metals: Risks vs Benefit

Summary:

Benefits: \$18-20 million in new mining wages in the community

Risks: Conservatively threatens loss of \$18-\$21 million in local income in the four townships surrounding Ely, due to loss of amenity-based residents, and slowdown in township housing market. Additional risk of loss of \$7-\$10 million in outside tourism spending related to BWCAW, possibly much more. **Total potential income loss: \$25-\$31 million**

The Debate:

Industry has miscast the debate as: "Mining vs Tourism"

Tourism has a role in amenity-based economy, but is not, by itself, the foundation for a strong and stable economy. Tourism attracts outside dollars seasonally and provides the ongoing flow of visitors, some of whom will become residents. Amenity-based residents provide a local and sustainable source of income that fuels the local economy.

This is what is threatened by Twin Metals.

The Townships and the amenity-based economy:

Ely's surrounding townships are home to a diverse mix of relatively high income permanent and seasonal residents who drive the Ely economy through their spending. Their total income exceeds the annual income generated by all residents of Ely by a significant margin. The townships represent Ely's "Golden Goose" in the sense that their year-round spending maintains viability for Main Street businesses.

Average & total income of residents

Twp./City	Avg. income	Total income
Eagles Nest	\$60,000	\$7.5 million
Fall Lake	\$74,000	\$20.7 million
Morse	\$76,825	\$45.4 million
Stony River	\$47,500	\$4.3 million
Total income/townships		\$77.9 million
City of Ely	\$45,800	\$77.0 million

Source: U.S. Census/American Fact Finder
Does not include seasonal residents

New housing units 2000-2010

Twp./City	Number	% increase
Eagles Nest	131	37%
Fall Lake	134	17%
Morse	219	19.6%
Stony River	33	9.5%
Total units	517	20%
City of Ely	110	5.7%

Source: U.S. Census/American Fact Finder
Includes both permanent and seasonal housing

Housing growth

From 2000-2010, the townships saw a 20 increase in housing, totaling 517 new units based on census data. The entire city of Ely saw 110 new housing units during the same period. Housing drives numerous sectors of the economy, including construction, real estate, finance, insurance, and retail. Assuming an average new home price of just \$150,000, new housing in the townships generates \$7.8 million in mostly local spending. The one exception to the township growth trend is Stony River, where the bulk of Twin Metals exploratory drilling has taken place. Housing growth there was less than half of other Ely area townships. If this is connected to Twin Metals' activity, this should be a major concern.

What attracts people to live in the townships?

Township study by U of M-Morris researchers found:

➤ Top 8 reasons for choosing to live in the area: Nature/Environment/Wildlife, Solitude and Privacy, Beauty, Peace/Quiet, Recreation, BWCA/lake access, Enjoy area/quality of life, Clean undeveloped environment.

These are lifestyle reasons. People are NOT locating in the townships for existing jobs. They are bringing their jobs or incomes with them or creating new opportunity locally.

Township study also asked residents what kinds of activities would cause them to leave the area. Mining topped the list, with 23 percent indicating they would consider leaving if mining was approved.

Most township residents oppose sulfide mining

Attitudes in the townships differ sharply from the city of Ely. Bill Hansen was the top vote-getter in every outlying township from Ely in the 2015 DFL primary. In a four-way race, Hansen received 62 percent of the vote in Stony River, 56 percent in Fall Lake, 57 percent in Eagles Nest, and 37 percent in Morse. By contrast, Hansen received 24 percent of the vote in Ely.

The economic risk:

Were mining to create an outmigration of some current residents, Ely stands to lose more in terms of local income to sustain its economy than mining would generate.

Compare the numbers:

Twin Metals: Projects 650 jobs, but given the trend of mechanization in the industry that would likely be 500 jobs by the time a mine could open, 15-20 years from now. BLS statistics show an average wage for a miner of \$72,365. But that is when miners are working. In the real world, they are subject to frequent layoff. Over a ten-year period, assume 18 months on layoff, at 50 percent of usual salary. That equals an average annual salary of \$66,945.

Assume 60 percent of miners live and spend in the Ely area. This totals \$20 million in new income for the Ely area.

But what are the potential costs?

- If just 15 percent of township residents opt to leave, or seasonal residents visit less frequently, that represents a loss of approximately \$15-18 million in local income annually.
- If new housing development in the townships slows by just a third, that's a loss of approximately \$3 million annually.
- These numbers only reflect loss of income from existing or potential LOCAL residents.

➤ THIS DOES NOT INCLUDE LOST TOURISM \$\$

Potential lost tourism

- BWCAW traffic alone generates over \$25 million in annual income to the Ely economy, extrapolating from the recent study commissioned by Friends of the Boundary Waters. Perception of a pristine wilderness is critical to continued interest in visiting the BWCAW.
- Reducing visitation and spending by just 25 percent would represent a loss of approximately \$6-\$8 million annually.
- Add it all up: Potential loss of income of approximately \$24-29 million annually, perhaps much more.

It's unknowable right now, which makes it a significant risk.
An economic study should be done, which would be part of the Forest Service withdrawal study

Bottom line:

Mining may very well reduce total income that fuels the Ely's economy.

Other factors:

- Job numbers and overall local income generated by mining declines over time. CAN ONLY BE SUSTAINED BY NEW MINES .
 - That increases risks of environmental harm, intensifies industrialization and negative impacts that undermine the amenity-based economy.
-

- Amenity-based economy offers potential for sustained and diversified economic growth in locally-generated income, as long as the amenities that attract people to the area are not diminished.

Backing Twin Metals is high risk for limited reward

- Project is not currently economical
- Unlikely to happen within 15 years, if ever
- It provides NO REMEDY for Ely's current economic challenges
- Were a mine eventually built, it remains unclear whether the local economy would benefit, or suffer as a result.

Why seek renewal of leases?

- Renewal of leases doesn't make the project any more economical. Doesn't make it any safer or any less unpopular around the state, or in the townships.
- It only guarantees another 15-20 years of bitter division in the Ely area.
- It risks slowing new investment in housing and business by increasing the element of risk the longer the debate goes on
- It risks strangling the Golden Goose, even if mining never occurs.

The fight hurts Ely

- People don't like living in a community that is divided.
 - Local businesses are being targeted for online attacks
 - This is an unhealthy dynamic that only harms Ely's efforts to build its amenity-based economy
-



Township impact

In copper-nickel debate, we all should consider economic costs as well as gains

08/3/2017 By: Marshall Helmberger

<http://www.timberjay.com/stories/township-impact,13545>

Anyone in business knows that a company's revenues account for only half of their financial equation. A business whose costs exceed its revenues is a business in trouble. The same calculus applies to local economies and must be considered as a community contemplates the implications of a major economic development project. Almost every development comes with direct costs, indirect costs, and potential risks. And every community should seek to understand those downsides as residents contemplate the wisdom of any project. Considering the benefits without weighing potential costs would be economic and political malpractice.

As the Ely area debates the merits of a copper-nickel mine, it is critical for residents and local political leaders to recognize that there are benefits, costs, and potential risks associated with any such proposal. We hope our story (see page 1), provides a starting point for discussion on that subject.

We used census data, election results, and academic studies, to better understand the differences in income levels, housing growth, and attitudes towards copper-nickel mining between residents of the city of Ely and residents of the outlying townships that factor heavily into Ely's economy. And we used those results to make estimates of the potential costs, in lost income, to the local economy.

A new mine would undoubtedly generate significant new income to the Ely area economy, mostly through the wages paid to mine workers. But if those gains are offset by income losses due to decisions to leave the area by some of the many residents of the townships who strongly oppose the opening of a sulfide mine in their watershed, the Ely area has assumed substantial environmental risk for little, if any, economic gain. Our analysis assumes that a dollar of income is worth the same to the local economy, whether it's spent by a copper-nickel miner or by a retiree who spends their pension and Social Security proceeds to live in the North Country.

Using this assumption, we looked at the data, made assumptions which we describe in our report, and offered reasonable conclusions. We recognize that the data could support other conclusions as well. Our report is hardly definitive, but is illustrative of the kind of calculations that should be undertaken, preferably by actual economists hired by the Forest Service, before the area

considers whether to support a potential copper-nickel mine. That said, we believe our report's conclusions are well-supported by the available data, and are likely conservative.

Our look at the data revealed some interesting trends. Most disturbing was the fact that Stony River Township has experienced relatively little new housing, either permanent or seasonal, since intensive mineral exploration by Twin Metals got underway in the township. That's in sharp contrast to other townships in the area. Whether that's a coincidence or evidence that mineral exploration and the potential for mining is limiting local investment isn't clear, but it's a question worth exploring. Would other townships, such as Fall Lake, located downstream of a possible mine, be avoided as well were a mine eventually built? A University of Minnesota survey of residents in the townships suggests the answer may well be yes.

The data makes one critical point perfectly clear— the economic activity generated by the incomes of township residents and long-term investments in housing and other infrastructure, is undoubtedly a major factor in Ely's economy. And keep in mind, our analysis looks primarily at the economic impact of income generated by local residents, whether year-round or seasonal. Economic activity generated by outside visitors, i.e. tourists, is an entirely separate issue.

This is why the two-year federal study on the costs and benefits of a potential mine is so valuable, and why current efforts to short-circuit the study are ultimately risky, potentially even destructive, to Ely's economy. Residents of the area would benefit tremendously from the kind of thoughtful and informed exploration that the federal study could provide. We need to recognize that mining jobs represent only one side of the economic equation in Ely. Without understanding the potential costs, we're considering only one side of the ledger. Anyone in business knows you need both sides to make an informed decision.



Ely's golden goose

Township residents power Ely-area economy

08/3/2017 By: Marshall Helmberger

<http://timberjay.com/stories/elys-golden-geese,13540>

Editor's Note: The following is an analysis of the potential economic risks associated with copper-nickel mining in the Ely area. It relies heavily on census data, county records, election results, and findings from a 2014 survey of residents in the townships surrounding Ely and looks primarily at income generated by local residents (whether permanent or seasonal), not outside visitors. It includes conclusions and assumptions which are presented within the narrative. We believe this is the best available data and that the assumptions are conservative. We hope this will add to the current debate over the wisdom of pursuing copper-nickel mining in the Ely area.

REGIONAL— An economic study released last month, commissioned by the Campaign to Save the Boundary Waters, suggests that thousands of jobs could be lost across the Arrowhead were a copper-nickel mine built on the edge of the canoe country.

As the Timberjay reported at the time, one potential weakness of the study is its assumption that the negative impacts that a mine would likely have on what it terms the “amenity-based” economy could be extrapolated across all of St. Louis, Lake, and Cook counties, including the city of Duluth. Using that approach, the study's authors estimated potential job losses that were extremely high, as many as 22,000 across the region and a loss of \$1.6 billion in annual income.

At the Timberjay, we see numbers that high as unrealistic, primarily because it is unreasonable to project similar economic impacts across the entire Arrowhead from mining in the Ely area. Residents in Duluth, for example, would see few of the new jobs created by a potential new mine, nor would they see many of the potential job and income losses that could come from diminishing the amenity-based economic model that continues to develop in the Ely area. We think both the positive and negative effects of such a mine would be concentrated in the Ely area. So, as residents in our region continue to debate the merits of Twin Metals' proposal, the Timberjay is offering new data to the discussion, gleaned almost exclusively from government and academic sources.

We've reported in the past on the job creation estimates associated with the proposed Twin Metals mine, with current company estimates of 650 permanent jobs, with an average salary of close to \$80,000 a year. That's an estimated \$52 million in annual income to mine workers living

in the region. If 50 percent of those workers lived and shopped in Ely it would potentially inject up to \$26 million in local income each year into Ely's economy. That is the plus side of the ledger.

So what does the negative side of the ledger look like if, as critics of the mine fear, North Country enthusiasts choose to look elsewhere to invest in new homes and seasonal cabins should a new mine impact the local environment and the culture of Ely? A new mine could bring \$26 million in annual income to local residents. Could it also lead to the loss of existing or future local income if new investment in surrounding townships slows and some current residents choose to leave the area, taking their incomes with them? And, if so, how much?

To better understand this issue, and assess the potential downside risks of copper-nickel mining to Ely's economy, it is important to understand the townships that surround Ely, and how they differ (often significantly) from the city itself. The four townships we examined were: Eagles Nest, Fall Lake, Morse, and Stony River.

The townships differ from Ely in several ways, including: average annual income, housing stock growth, total property valuation, and views on mining. We'll look at the data on each of these topics. We'll also offer potential conclusions to better assess the level of economic risk that copper-nickel mining poses to the Ely area economy.

Household income

The income divide between the city of Ely and its surrounding townships is significant. According to the most recent census data, the average household income in the four townships is as follows:

‰ Eagles Nest: \$60,000

‰ Fall Lake: \$74,000

‰ Morse: \$76,825

‰ Stony River: \$47,500

Note that we used the mean, or average, rather than the median household income, because our goal was to determine total income to residents of each township, which is best determined by multiplying the average household income times the number of households.

Using this calculation, we can determine that year-round residents of the four townships earn approximately \$77.8 million annually, which represents income available for economic activity within the Ely area economy. The mean household income in the city of Ely is \$45,800. Using the same calculation for the city of Ely, with 1,681 total households, you get \$76.98 million in annual income. These calculations demonstrate the importance of the townships in generating income to the Ely area economy.

But this only tells part of the story, because it does not consider the impact of seasonal recreational property owners, who outnumber permanent residents of the townships by roughly two-to-one, and who spend a significant portion of their annual income in the Ely area as well.

Determining the annual household income of seasonal residents and other recreational property owners in the area is not possible, but we can assume it is greater than the average income for permanent residents, since most of these property owners are living in urban areas where incomes tend to be greater. For the purposes of our analysis, we assumed that seasonal and recreational property owners earned 25 percent more than year-round residents (which we believe is conservative).

We also assumed that seasonal and recreational property owners utilized their residences an average of six weeks a year, and spent 20 percent of their income on living expenses while in the area or on maintenance, utilities, insurance, and other expenses related to their seasonal residence, many of which are incurred year-round.

Adding seasonal recreational income on this basis adds \$31.37 million to the total available for economic activity in the Ely area. We recognize some of that season recreational property is owned by residents of Ely proper, and we are deducting ten percent to account for that, giving a grand total of added income to the area of \$28.3 million.

This leaves a grand total of \$106 million in annual income generated by residents in the townships, compared to \$76.98 million generated by residents of Ely.

Growth in housing

While growth in housing is relatively modest throughout northern St. Louis County, it is relatively robust in three of the four townships surrounding Ely, and seasonal residences dominate the new construction. We compared census data from 2000 and 2010, and during that decade the four townships saw the following growth in housing stock:

Eagles Nest: 27 percent overall, 26 percent in seasonal recreational.

Fall Lake: 14 percent overall, 22 percent in seasonal recreational.

Morse: 16 percent overall, 21 percent in seasonal recreational.

Stony River: Two percent overall, 11 percent in seasonal recreational.

By contrast, Ely experienced five percent growth in housing stock over the decade. That means Ely added 110 new housing units over the decade, or an average of 11 new units annually. The townships, by contrast, added 517 units over the same period, or just under 52 per year. For those sectors reliant on housing stock growth, such as construction, building supplies, excavators, well drillers, finance, insurance, home furnishings, the housing growth in Eagles Nest, Morse, and Fall Lake townships is a critical element of Ely's economy.

Assuming a relatively conservative average overall construction price of \$150,000 for a new housing unit in the townships, this sector alone would inject \$7.8 million annually into the Ely area economy.

Views on copper-nickel mining

At last week's scoping hearing on the proposed federal mineral withdrawal, Ely Mayor Chuck Novak claimed that 68 percent of the residents of Ely supported a new mine. Other data would tend to support that figure, within the city itself.

It is a much different story, however, in the townships, where the evidence points to majority or near-majority opposition to a new mine among permanent residents.

Consider the results of the 2015 DFL special election primary, which pitted three pro-copper mining DFLers against a candidate, Bill Hanson, who took a strong position against it. In a normal race, Hanson, who hails from Grand Marais, would have been unable to mount a strong bid in the Ely area, particularly with an Ely area candidate also in the race. But Hanson's position on mining enabled him to significantly outperform expectations in the townships. While Hanson garnered 23 percent of the vote in the city of Ely, he won 56 percent of the vote in the four-way race in Fall Lake, 57 percent in Eagles Nest, 62 percent in Stony River, and was the top vote-getter (albeit narrowly) in Morse, with 37 percent of the vote.

Such vote totals reflect the views of permanent residents, whereas there is general agreement in the area that the views of seasonal residents are even more strongly opposed to copper-nickel mining than these vote totals would suggest.

A 2014 survey of attitudes in the four townships paints a similar picture. The survey, completed by researchers from the University of Minnesota-Morris, enjoyed a strong rate of response from those who received the survey.

It asked, among other things, what qualities attracted township residents to the area. The vast majority cited their proximity to nature, outdoor recreational opportunities, solitude, and peace and quiet as the primary factors that keep them in the region.

When asked what factors would make them consider leaving the area, the single largest factor (named by 23 percent of respondents) was mining. Based on this data, it is apparent that a significant divide in views on copper-nickel mining exists between residents of the city of Ely and residents of neighboring townships.

Property valuation

Differences between the city of Ely and the four townships in terms of property valuation are equally stark. Morse and Fall Lake townships are among the highest value townships in northern Minnesota, with total estimated market value of \$414 million and \$345 million respectively. Eagles Nest Township's 2017 valuation is \$109 million, while Stony River's valuation is \$88 million. That's a combined valuation of \$956 million.

The valuation of all property within the city of Ely, by contrast, is \$164.5 million.

Economic studies have demonstrated that proximity to a mine, or other developments considered undesirable to most residential property owners, can negatively impact property values.

What does it mean?

The data presented here could support differing interpretations and predictions of the future, but several conclusions are well justified. They include:

- Collectively, both permanent and seasonal residents of the townships provide roughly six of every ten dollars of locally-based income available to generate economic activity in Ely.
- Collectively, the townships account for 82 percent of new housing construction activity in the Ely area. They provide an overwhelming amount of the real estate activity as well.
- While the permanent populations of the townships are currently static, the overall population of both permanent and seasonal residents is growing modestly in three of the four townships (Stony River being the exception). If that trend continues, it would continue to provide for income growth in the Ely area, resulting both from annual construction wages as well as from spending from growth in the overall number of seasonal residents.
- Majorities of both year-round and seasonal residents of the townships would view copper-nickel mining in the Ely area as a significant and negative development that could prompt a significant percentage to consider leaving the area. How large a percentage is unknown, and that presents an economic risk associated with a mining proposal.
- The sluggish pace of new housing construction in Stony River township from 2000-2015, which was a period during which mineral exploration activity was intense in the township, may reflect future conditions in other townships, particularly Fall Lake, were copper-nickel mining to commence.
- Should 15 percent of current township residents choose to leave the area or visit seasonal homes less frequently due to mining, it would lead to an initial loss of \$15.9 million in annual income to the Ely area economy. Should 20 percent of township residents choose to leave or visit less frequently, it would lead to an initial loss of \$21.2 million. Recall that based on the township survey, 23 percent said that mining was a factor that could prompt them to leave the area. As the recent study led by economist Spencer Phillips noted, approximately 42 percent of residents of the region rely on investment income and transfer payments, such as Social Security for their income, which leaves them much freer to leave an area if the attributes that currently keep them in the area are lost or impaired.

It is likely that most of these individuals would choose to sell their properties, many of which would be purchased by others, very possibly by new or existing residents working in a new mining operation. But substituting one income for another maintains the economic status quo. It does not generate economic growth. Given that average incomes for township residents are relatively high, replacing current township residents with future miners provides little gain in overall local income.

- The potential losses in local income would compound with time due to lost growth. From 2010-2015, according to census data, average income in Morse and Fall Lake Townships increased by 3.2 percent annually, which added approximately \$2.1 million per year in local income to the Ely area without accounting for the impact of new seasonal residents investing in, and spending time in, the townships. By contrast, incomes for Ely residents have remained static over the past five years, according to census data. It is reasonable to conclude that the economic importance of the

townships to the Ely area economy would continue to increase over time, barring a development that discourages new investment in the townships and slows or halts the increase in township incomes due to the loss of high earners who choose to leave the area. This could be considered an “opportunity cost” of mining, as the Ely area loses income gains that township residents might otherwise accrue.

- The introduction of mining would likely have a considerable negative impact on future growth in seasonal recreational real estate purchases and housing unit construction in the townships. That appears to already be happening in Stony River Township due to the impact of intensive mineral exploration there. The start-up of mining, on the other hand, may increase housing construction within the city of Ely, which could partially offset a decline in construction in the townships.
- Based on consistent historical trends, overall local wage income derived by residents employed in a copper-nickel mine would tend to decline over time given increasing mechanization and productivity gains. For example, it required four times as many mine workers in 1979 to produce the same tonnage of taconite as is produced on the Iron Range today. Economists project that the pace of mechanization will only increase, leading to less overall wage income generated by any operating mine over time.
- Stability versus boom and bust. The amenity-based economic model that is well-established in Ely’s townships provides a relatively robust, predictable, and steadily growing source of income to local residents that generates activity within the local economy. A copper-nickel mine would provide a robust source of local income during boom years, but would provide significant economic stress during the cyclical downturns inherent in the mining industry. Mining busts create significant economic dislocation and hardship in mining-dependent communities. That is a conclusion well supported by historical data.

Impact of lost tourism

None of this analysis considers potential impacts to what is typically called the tourism economy, which focuses on income generated through visits by non-residents. A recent study that looked solely at income generated by outside visitors utilizing the Boundary Waters Canoe Area Wilderness, concluded that the wilderness generated about \$57 million in annual income to the communities of Ely, Tofte, and Grand Marais. Were negative perceptions about copper-nickel mining within the wilderness to affect visitation, the costs would almost certainly be focused in the Ely area, where the effects of the mine would be most pronounced. Conservatively, 50 percent of wilderness visits emanate from Ely.

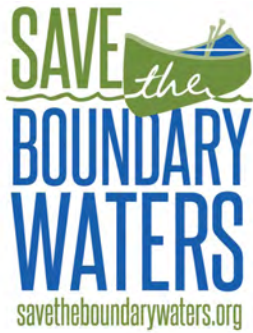
Were wilderness visits beginning from Ely area accesses to decline by 25 percent due to negative perceptions of sulfide mining within the wilderness watershed, it would result in the loss of more than \$7 million in annual local income. Keep in mind that wilderness visits comprise only a portion of the total visitor spending in Ely. The total impact on visitor spending could be significantly greater than \$7 million annually.

Conclusions

While the opening of a copper-nickel mine near Ely would provide a significant new source of local income to the community, it would not come without significant economic risks, which could offset or even exceed the benefits of a mining venture.

Based on this analysis, it is reasonable to assume that the opening of a mine could lead to the initial loss of anywhere from \$22.9 million to \$28.6 million in local income, a figure that would likely increase over time.

This assumes losses based primarily on public perception of the loss of wilderness attributes in the Ely area. Significant documented environmental impacts, a major spill, or a catastrophic event, such as a tailings basin breach, could significantly increase the downside risks to the Ely area economy.



Twin Metals Minnesota Mine: A Case Study in the Economic Costs of Sulfide-Ore Copper Mining

... it is reasonable to assume that the opening of a [Twin Metals] mine could lead to the initial loss of anywhere from \$22.9 million to \$28.6 million in local income, a figure that would likely increase over time. Ely Timberjay news story 8/3/17

This is why the two-year federal study on the costs and benefits of a potential mine is so valuable, and why current efforts to short-circuit the study are ultimately risky, potentially even destructive, to Ely's economy. Residents of the area would benefit tremendously from the kind of thoughtful and informed exploration that the federal study could provide. We need to recognize that mining jobs represent only one side of the ledger. Anyone in business knows that you need both sides to make an informed decision. Ely Timberjay editorial 8/3/17

An economic analysis published by the Ely Timberjay on August 3, 2017 provides an in-depth look at some of the potential economic costs associated with a proposed sulfide-ore copper mine in the Ely area. This analysis is a case study of one specific mine proposal, the Twin Metals mine, and the economic impact it would have on income generated by local residents in the Ely area (Ely and four surrounding townships—Morse, Fall Lake, Eagles Nest, and Stony River).

The Timberjay study is not to be confused with a recent [report](#) by Key-Log Economics that looked at the effects of sulfide-ore copper mining in the larger watershed of the Boundary Waters Canoe Area Wilderness. The Key-Log report covered over 234,000 acres of federal lands in which there has been extensive prospecting by multiple mining companies, and extrapolated impacts in multiple economic sectors across the three-county (St. Louis, Lake, and Cook) Arrowhead Region that is home to the Boundary Waters. The stark findings of the Key-Log report show that sulfide-ore copper mining in the Boundary Waters watershed could cause the Arrowhead Region to lose up to \$288 million in annual visitor spending, 4,490 jobs in tourism, 22,791 jobs in the rest of the economy, \$1.6 billion in annual income, and \$509 million in property value.

Because the Timberjay study is limited to one potential mine and its impact on one community within the watershed it is not as comprehensive as the Key-Log Report. However, it provides a sobering look at what could happen to the Ely area if the Twin Metals sulfide-ore copper mine were developed. The full Timberjay analysis can be viewed [here](#), but among the important findings are:

- Majorities of both year-round and seasonal residents of the four townships view copper-nickel mining in the Ely area as a significant and negative development that could prompt a large

percentage to consider leaving the area. Based on a four-township survey by the University of Minnesota-Morris, 23 percent said that mining was the most important factor that would prompt them to leave the area.

- Collectively, permanent and seasonal residents of the four townships provide roughly six of every ten dollars of locally-based income available to generate economic activity in Ely.
- Collectively, the townships account for 82 percent of new housing construction activity in the Ely area. They provide an overwhelming amount of the real estate activity as well.
- Mining would likely have a negative impact on growth in recreational real estate purchases and housing unit construction in the townships. The low rate of housing construction in Stony River township from 2000-2010 was a period during which mineral exploration activity was intense in the township (Chart B, below). Proximity to mines negatively impacts property values.
- The full-time population of the townships is static, but the number of seasonal residents is growing in three of the four townships (Stony River being the exception). That trend provides income growth in the Ely area from annual construction wages and from spending by the additional seasonal residents.
- If 15 percent of township residents choose to leave the area or visit seasonal homes less frequently because of mining, it would lead to an initial loss of \$15.9 million in annual income to the Ely area economy. If 20 percent of township residents choose to leave or visit less frequently, the initial loss would be \$21.2 million. As the recent study led by economist Spencer Phillips noted, approximately 42 percent of residents of the region rely on investment income and transfer payments, such as Social Security, for their income, which leaves them much freer to leave an area if the attributes that currently keep them in the area are lost or impaired.
- The potential losses in local income would compound with time because of lost growth. From 2010-2015, according to census data, average income in Morse and Fall Lake Townships increased by 3.2 percent annually, which added approximately \$2.1 million per year in local income to the Ely area without accounting for the impact of new seasonal residents investing in, and spending time in, the townships. By contrast, incomes for Ely residents have remained static over the past five years, according to census data.

Finally, this analysis concludes:

Based on this analysis, it is reasonable to assume that the opening of a [Twin Metals] mine could lead to the initial loss of anywhere from \$22.9 million to \$28.6 million in local income, a figure that would likely increase over time.

This assumes losses based primarily on public perception of the loss of wilderness attributes in the Ely area. Significant documented environmental impacts, a major spill, or a catastrophic event, such as a tailings basin breach, could significantly increase the downside risks to the Ely area economy.

The data makes one critical point perfectly clear – the economic activity generated by the incomes of township residents and long-term investments in housing and other infrastructure,

is undoubtedly a major factor in Ely's economy. And keep in mind, our analysis looks primarily at the economic impact of income generated by local residents, whether year-round or seasonal. Economic activity generated by outside visitors, i.e. tourists, is an entirely separate issue.

Chart A
Average & total income of residents

<u>Twp./City</u>	<u>Avg. Income</u>	<u>Total Income</u>
Eagles Nest	\$60,000	\$7.5 million
Fall Lake	\$74,000	\$20.7 million
Morse	\$76,825	\$45.4 million
Stony River	\$47,500	<u>\$4.3 million</u>
Total income/ townships		\$77.9 million
Total income w/seasonal residents		\$106 million
City of Ely	\$45,800	\$77.0 million

Source: U.S. Census/ American Fact Finder
Does not include seasonal residents

Chart B
New housing units 2000-2010

<u>Twp./City</u>	<u>Number</u>	<u>% increase</u>
Eagles Nest	131	37%
Fall Lake	134	17%
Morse	219	19.6%
Stony River	33	9.5%
Total units	517	20%
City of Ely	110	5.7%

Source: U.S. Census/ American Fact Finder
Includes both permanent and seasonal housing

Chart C
Property values

<u>Twp./City</u>	
Eagles Nest	\$109 million
Fall Lake	\$345 million
Morse	\$414 million
Stony River	<u>\$ 88 million</u>
Total	\$956 million

City of Ely \$164.5 million
Source: St. Louis County and Lake County Property Tax Records