Analysis of Proposed 20-year Mineral Leasing Withdrawal in Superior National Forest[1]

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June 24, 2019

Abstract

The Rainy River Watershed on the Superior National Forest is home to the Boundary Waters Canoe Area Wilderness (BWCAW). It also contains deposits of copper, nickel, and trace metals, and copper-nickel mining has been proposed adjacent to and upstream of the BWCAW. This sets up a potential tradeoff between economic benefits from mining and concerns about negative economic consequences of that mining on the local recreational and amenity-based economy. Existing studies of mining in the Superior National Forest focus on static effects on a single industry (e.g. mining) at some unspecified point over a medium-run horizon. We draw on these studies and the economics literature to provide a unified analysis of the effect of the proposed mining development on income and employment over time. Our results suggest that the proposed development would lead to a boom-bust cycle that is typical of resource extraction economies, exacerbated by the likely negative effect on the recreation industry.

Keywords: Economic impact analysis, resource extraction, recreation economy, mining economy

Declaration of interest: None

[1] An earlier draft of this study was initially submitted on August 6, 2018, in letter form, as a comment on the U.S. Forest Service's proposed withdrawal of Superior National Forest land within the Rainy River Watershed from mineral leasing. This revision reflects several updates to the 2018 letter. The most significant of these is that, in the 2018 letter considered only direct and indirect employment and income. In response to comments received on the original letter, the current revision now includes estimates of induced (spillover) employment and income. This revision also incorporates several other changes. For internal consistency, multipliers are now taken solely from UMD-Labovitz (2012) for mining and from Hjerpe (2018) for recreation. Additionally, wage rates are all for the Arrowhead county region whereas in the 2018 letter, some wage rates were statewide. The discussion of related academic literature has been expanded, and procedural recommendations to the US Forest Service made in the 2018 letter have been removed from this version. Taken together, the revisions affect numerical values in the 2018 letter but do not change the conclusions.

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1. Introduction

The Boundary Waters Canoe Area Wilderness (BWCAW), located within the Superior National Forest in northeastern Minnesota along the Canadian border, consists of more than one million acres of connected lakes and rivers. The BWCAW is one of the most visited wilderness areas in the United States, with 150,000 visitors in 2015 (US Forest Service 2016), and its visitors support a varied outdoor recreation industry in gateway communities, primarily Ely, Minnesota (Hjerpe 2018). The lakes and rivers outside the BWCAW also attract recreational visits and both seasonal and permanent residents who locate there for the outdoor and lakes amenities.

The region also has rich mineral deposits. The Mesabi Iron Range, the largest iron mining district in North America, extends for nearly 100 miles to the southwest of the BWCAW, with its most northeasterly portion within ten miles of the wilderness boundary (Minnesota Department of Natural Resources 2017). Although its high-grade iron ore (hematite) has been mined out, taconite mining continues, and taconite mining operations employed 3440 workers in 2016 (Minnesota DNR 2017). In addition, there is commercial interest in developing copper-nickel mines in deposits both in and out of the Superior National Forest.

In particular, a copper-nickel mine, the Twin Metals Mine (TMM), has been proposed for a site bordering and immediately upstream of the BWCAW. The mining rights for the site were originally granted in 1966 for a 20-year period with up to three 10-year renewals. The first two of these renewals were granted, but in December 2016 the Bureau of Land Management (BLM) denied the third renewal request.[3] In January 2017 under the Obama Administration, the U.S. Forest Service further proposed to withdraw from mineral leasing approximately 234,000 acres of federal lands within the Rainy River Watershed, which flows north into the BWCAW and which contains the TMM project, and it also initiated the preparation of an environmental impact statement (EIS) to assess the proposed withdrawal.[4] In September 2018, the Trump Administration cancelled the withdrawal application and EIS[5], and in May 2019 the BLM reversed its 2016 denial and renewed the TMM leases. The mine awaits federal and state permitting, and the federal lease renewal is currently being litigated.

[3] Thomas Tidwell, Chief, BLM, Memorandum "Lease Renewal Application Rejected," December 15, 2016 at https://www.blm.gov/download/file/fid/7652.
[4] 82 FR 4282.
[5] https://www.usda.gov/media/press-releases/2018/09/06/usda-removes-roadblock-mineral-exploration-rainy-river-watershed).

The proposed TMM mine raises a classic conflict between recreational use and conservation on the one hand and mining development on the other, a conflict made more stark by the unique attributes and wilderness status of the BWCAW. Proponents of the mine point to the jobs and income it will create (University of Minnesota-Duluth 2012, Orr et. al. 2018). Opponents point to the risks to the watershed because of potential acid mine drainage and toxin release (Myers 2016, Pearson et al. 2019), noise and light pollution that would disrupt the wilderness experience proximate the mining operations and negatively impact the local recreational industry (US Forest Service 2016), and potential reductions in amenity-based in-migration (Sungur et al. 2014).

While there have been reports issued on both sides of the issue[6], those reports tend to look at snapshots in time, use different assumptions, and do not provide an integrated comparisons of the economic costs and benefits of the proposed withdrawal.

Our study aims to fill this gap by providing an accounting of the impacts over time of potential development of copper-nickel mining adjacent to the BWCAW on regional incomes and employment. We focus on the proposed TMM project because it is the sole copper-nickel mine currently proposed for the Rainy River watershed. We consider a 20-year horizon, which is the horizon of the Obama Administration's proposed mineral rights withdrawal. Because the focus is on the TMM project, the economic analysis focuses on the greater Ely, MN region including usage of the Boundary Waters Canoe Area Wilderness (BWCAW) and recreational use in the region in addition to the BWCAW. Our analysis draws on relevant regional and industry data, modeling in previous economic studies of the withdrawal, and the related economics literature. Our income concept is earnings from employment in industries directly affected by the project (so-called direct income), earnings from jobs along the supply chain (indirect income), and earnings from jobs resulting from the additional direct and indirect income (induced income).

One of the challenges in this undertaking is the uncertainty around each of the many assumptions needed for this calculation. Although historical data inform distributions for some our parameters, but for others there is no evident way to calibrate a distribution, and moreover some of the parameters could covary and no data is available to quantify those covariances. As a result, a textbook treatment of uncertainty, for example using Bayesian or Monte Carlo methods, is not practical in this situation. We therefore use a

[6] University of Minnesota-Duluth (2012), Hjerpe and Phillips (2013), Sungur et al. (2014), Barber et al. (2014), Minnesota DNR (2015) Phillips and Alkire (2017), Helmberger (2017), Hjerpe (2018), Ward (2018), and Orr et. al. (2018).

multiple scenario approach, which (as we explain) results in 72 different scenarios which in turn generate 72 different time paths for income and employment over the 20 years.

We find that, in all our scenarios, mining would produce an initial but temporary net growth of employment and income. Over time, the economic benefits of mining tends to be outweighed by the negative impact of mining on the recreational industry and on in-migration, leading to a boom-bust cycle. Second, the preponderance of our scenarios indicate negative net present values of income resulting from the mining project. The primary drivers of this longer-run decline in incomes are increasing productivity in mining (estimated using historical data), reduced amenity-based in-migration, and reduced recreational demand. This boom-bust finding is consistent with recent papers on boom-bust cycles in extractive resource development.

The scope of this study -- incomes and employment -- is intentionally narrow, and we have omitted many additional factors which are likely important. These omitted factors include: effects on real estate values in the region; proprietors' income and profits; the value of the BWCAW and Superior National Forest as a regional attractor of talent in the Duluth area and elsewhere; and the employment and income driven by the BWCAW and Superior National Forest elsewhere in the state. We also do not consider non-market benefits such as non-market ecosystem services and wilderness existence values.

We first develop our scenarios and present the net present value calculations. We then discuss factors omitted from this analysis and discuss our results in the context of the relevant academic literature.

2. Computing Costs and Benefits over a 20-Year Horizon

Our approach is to compute annual employment and income for the 20 years of the proposed withdrawal under two cases: the base case of the status quo in which there is no mining, which corresponds to a withdrawal of mineral rights, and the alternative in which the TMM mine is developed. In addition, we compute the net present values of the differences in income between the two cases.

We consider direct, indirect, and induced employment and income effects of the TMM case, relative to the base case. Direct employment is in the industries under study (mining and recreation). Indirect employment is in industries that serve the industry or project under study, for example in the case of mining, the change in employment in industries that provide mining services such as equipment repair. Induced employment is the employment resulting from the spending of direct and indirect income on

local goods and services. The direct and indirect income effects of the TMM counterfactual in a given year are the net effect on incomes from direct and indirect employment in mining and recreation of the TMM project, relative to the withdrawal case, plus the net direct effect on income from those attracted to the region by amenity values. This latter term captures the income spent in the region by those who choose to live in the region because of its amenity effects, and whose decision to live in the region might be affected by the withdrawal/no withdrawal decision.[7]

Induced income and employment are "spillover" effects of direct and indirect earnings which operate through a Keynesian multiplier channel.[8] Because mining jobs are better-paying than recreation jobs, a job in mining will result in more induced employment and income than a job in recreation. Whether induced employment and income effects actually materialize depends on the availability of unemployed or underemployed resources locally. If there is economic slack, then the direct and indirect earnings can create new local jobs. If, however, the economy is already at full employment, then what is calculated as induced employment either substitutes for other employment as workers change jobs or creates local jobs by expanding the work force as out-of-region workers move into the area. Recent empirical evidence in Auerbach et. al. (2019) suggests that on average over periods of recession and expansion, there are nonzero induced local income and employment multipliers. The induced multipliers we use, which are taken from the IMPLAN studies of the Arrowhead economy, fall in the range estimated by Auerbach et. al. (2019).[9]

[7] We compute indirect employment from direct employment using indirect/direct proportionality factors from the IMPLAN model results reported for non-ferrous mining by UMD-Duluth (2012, Table 25) (Arrowhead region plus Douglas County, Wisconsin) and for recreation/hospitality by Hjerpe (2018, Table 5) (northeast Minnesota). Direct and indirect labor incomes are computed from direct and indirect employment using wage rates for 2016 for the Arrowhead region as discussed below.

[8] Of the four studies related to the withdrawal that use the IMPLAN model (UMD (2012), Minnesota DNR (2015), Hjerpe (2018), and Orr et. al. (2018)), only Hjerpe (2018) and Orr et. al. (2018) report labor income. The (induced/(direct + indirect)) labor income multipliers computed from results in Hjerpe (2018) and Orr et. al. (2018) are respectively 0.214 and 0.347. With constant marginal propensities to consume out of labor income, the induced income multiplier should be the same for income earned regardless of its source (e.g., mining or recreation). One difference between the two studies that could account for these different multipliers is that Orr et. al. (2018) consider state-wide effects whereas Hjerpe (2018) restricts effects to the northeast Minnesota region. Because the focus of our analysis is regional, not state-wide, we use the multiplier 0.214. This induced income multiplier is in line with the (induced/(direct + indirect)) value added multiplier of 0.18 in UMD (2012), which is for the Arrowhead region plus Douglas County, Wisconsin. We compute induced employment from induced labor income using Arrowhead tri-county average wages for 2016. If the larger, state-wide induced multiplier of 0.347 is used, the numerical results change but the qualitative results, both for incomes and employment, do not.

[9] Auerbach et al. (2019) use US Department of Defense spending at the local region level and find that, for each $1 of US DOD spending in a locality, GDP in that state goes up by $1.50, so that the GDP multiplier ((indirect + induced)/direct) is 0.50. Their data covers 1997-2016 so includes both the strong labor markets of the late 1990s and mid-2000s and the long period of slack during and recovering from the financial crisis recession. Their estimate of an induced GDP multiplier of 0.50 is consistent with IMPLAN output multipliers. Hjerpe's (2018, Table 5) IMPLAN output multiplier ((indirect + induced)/direct) is 0.59 regionally (not state-wide) for recreation income.

The construction of our scenarios entails developing benchmark assumptions for employment and income under the case of the withdrawal, then considering alternative assumptions under the TMM counterfactual. To capture uncertainty, we vary key parameters to generate a total of 72 scenarios.

For our employment calculations, we make the following assumptions. For the case of the withdrawal, absent extant third-party growth forecasts of recreational employment in the greater Ely area, we rely on two sources of growth in employment related to recreation. In the Arrowhead region (St. Louis, Lake, and Cook counties), employment in the tourism and hospitality industries from 2012 to 2016 grew by 1.4% per year (MNDEED). USDA (2016) provides projections of increased recreational usage by category for 2008-2030; for the category "Backcountry/challenge" the annualized growth rate of user-days is 1.2%. We use this latter, lower value as the baseline in the withdrawal scenario because it is more directly relevant to BWCAW usage rather than outdoor recreation generally. Although Arrowhead region employment in recreational industries is available, we are unaware of data on the recreational employment base potentially specifically affected by the TMM project. Full Arrowhead region recreational employment (tourism and hospitality) in 2016 was 13,616, however that includes activity not likely to be directly impacted by the mining, such as hotels and restaurants serving University of Minnesota-Duluth and Duluth hospitals. Using the IMPLAN model and a survey of actual user expenditures, Hjerpe (2018) estimates that BWCAW visits from out-of-region visitors alone supports 879 direct jobs. Use of the BWCAW is just one way that recreational users take advantage of the outdoors in the region, so jobs potentially affected include more than just those supported by BWCAW out-of-region users. We therefore approximate the narrow direct employment definition from Hjerpe (2018) as accounting for one-fourth of potentially affected jobs. The full Superior National Forest area extends well to the east of Ely. For this reason, the assumption of 3516 affected direct jobs could be an underestimate. We therefore consider an alternative case in which the number of affected direct jobs in tourism and recreational is 50% greater, 5274, which is still less than two-fifths the number of recreational and tourism jobs in the tri-county area.

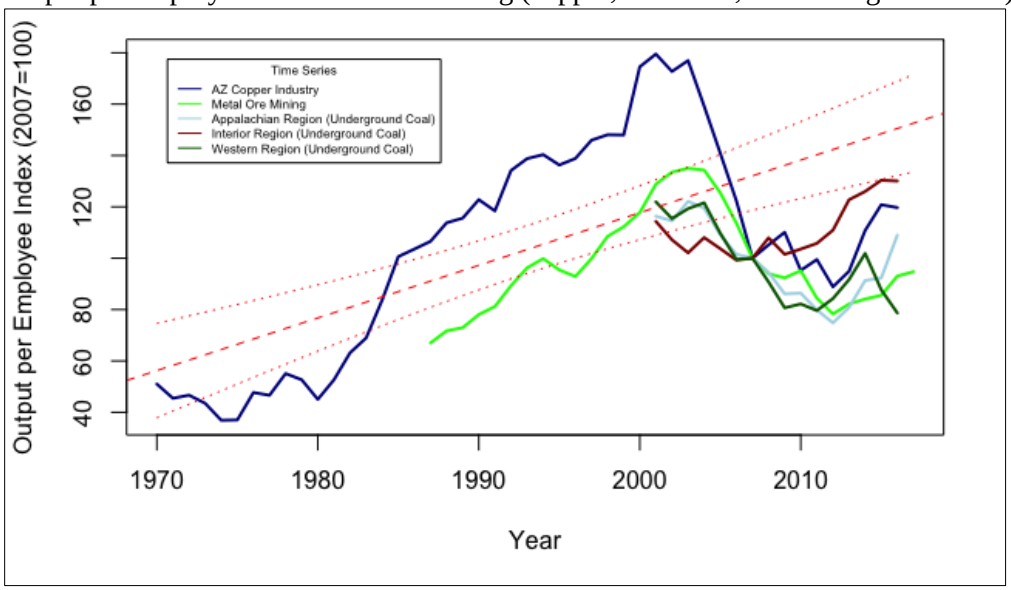
Under the TMM counterfactual, in our high-mining scenario, we assume that TMM direct employment starts at 650 jobs, a figure taken from TMM materials (TMM (2018); Barber et al. 2014). We consider this estimate to reflect the high end of direct mining employment. The UMD-Duluth (2012) study

UMD's (2012, Table 25) regional GDP IMPLAN multiplier ((indirect + induced)/direct) is 0.43 for non-ferrous mining. The PolyMet FEIS (2015, Table 5.2.10-2) output multiplier is ((indirect + induced)/direct) is 0.55. Orr et al.'s (2018, Table 1) state-wide GDP IMPLAN multiplier ((indirect + induced)/direct) is 0.48.

projected 427 direct employment jobs in non-ferrous mining. In addition, in May 2018 TMM announced that it would scale back the planned mining from 50,000 tons per day to 20,000 tons per day. A proportional employment reduction of the TMM 650 jobs at 50,000 tons/day yields 260 direct employment jobs. We therefore consider two additional mining scenarios, intermediate, at 427 direct jobs, and low, at 260 direct jobs.

As shown in Figure 1, non-ferrous mining generally, and copper mining specifically in the US, has exhibited substantial gains in productivity. Using the data in Figure 1, we consider three mining productivity growth scenarios.[10] In all, this generates nine paths for annual mining employment (three initial levels, three productivity growth rates).

Figure 1. Output per employee in non-ferrous mining (copper, metal ore, and underground coal), index.



Sources: US Energy Information Administration, Arizona Department of Mines and Mineral Resources, US Geological Survey, US Bureau of Economic Analysis, US Bureau of Labor Statistics.

Under the TMM counterfactual, we consider two paths for recreational employment, a low-impact path and a high-impact path. Because we are not aware of a directly comparable project (large-scale copper-sulfide ore mining proximate to a water-based wilderness area) for which there are historical data, we

[10] Figure 1 shows an overall positive trend in labor productivity (tons per hour) in the Arizona copper industry from 1970 to 2016; across all hard rock metal mining from 1987 to 2017; and in underground coal mining across the three major U.S. coal producing regions from 2001 to 2016. The declines in output per employee in the mid- to late-2000's are associated with temporary changes in global commodity prices. We assume a baseline of 2.1% productivity growth per year which is the average growth rate in the Arizona copper industry. We incorporate uncertainty using low and high productivity growth scenarios of 1.4%, and 2.7%, which are the end points of a 95% confidence interval for productivity growth estimated from the Arizona data. We assume a constant annual extraction rate, so that employment falls by the rate of growth of productivity for the three productivity scenarios.

consider a scenario in which recreational employment contracts at the rate of 1.2% per year and another in which it contracts at the rate of 2.4% per year. The first of these rates reverses the growth projected under the USDA baseline (USDA 2016). The second of these rates is a reversal of twice the growth projected under the USDA baseline (USDA 2016).[11] These counterfactuals are in line with previous studies of growth of other US amenity-based regional economies.[12] We consider the high-impact scenario conservative in the sense that the impact on tourism over the long run of a major spill or acid mine drainage event are plausibly substantially more consequential.[13]

For the income scenarios, the incomes associated with direct mining and recreational employment are computed using average local wage rates in those industries (MNDEED). Employment in indirect and induced jobs are assumed to earn the average wage for the tri-county region in 2016 (MNDEED).

[11] Rasker and Hackman (1996) examine employment and income trends in northwestern Montana and find that from 1969 to 1992, employment in counties characterized by pristine wilderness grew by 93%, an annualized rate of 2.9%. In contrast, resource-extractive counties observed employment growth of 15% over the same period, an annualized rate of 0.6%, a difference of roughly 2.3%. The scenario in which recreational employment contracts at the rate of 1.2% represents a difference of roughly 2.4% with respect to the withdrawal scenario. Thus, our rate of a 1.2% contraction in hospitality employment is reasonable assuming a reversal of Rasker and Hackman's (1996) estimate and is perhaps conservative given the degree to which hospitality and tourism employment is amenity-dependent.

[12] Rasker and Hansen (2000) examine rural counties in Idaho, Montana, and Wyoming and find that ecological and natural amenity variables are correlated with population growth in these areas. Deller et al. (2001) find similar results, finding a positive relationship between population growth and publicly owned land resources related to tourism. Winkler et al. (2007), find that "New West" communities, areas typically characterized by amenity migration, see anywhere from 38% to 195% higher employment in the tourism industry when compared to "Old West" communities. According to Winkler et al. (2007), this transition from "Old" to "New West" economic models has occurred over a 30-year period, which would imply an annual growth rate of between 1.2% and 6.5%. Empirical evidence supports the assertion that amenity-driven growth has supplanted extractive industries as the foundation of many amenity-rich, rural western counties (Lorah and Southwick, 2003). Rasker, Gude, and Delorey (2013) find a positive relationship between growth in employment and proximity to protected public lands using data on federal lands in non-metropolitan Western counties. Henderson and McDaniel (2005) study sector-level employment growth and USDA natural amenity indices in more than 2,000 rural U.S. counties, and find a statistically-significant, positive relationship between landscape amenities and service sector employment growth.

[13] The environmental risks associated with sulfide-ore copper mining within the watershed of the BWCAW are potentially economically consequential. Mining and beneficiation processes for underground copper ore generate large volumes of tailings. In a watershed hydrology model of possible mining locations in northeastern Minnesota, Myers (2016) finds that even relatively short-term leaks of tailing materials on the surface at mining locations in the region could cause substantial loads of sulfate, a major product of acid mine drainage, in the rivers and valuable downstream resources of the BWCAW. When considering the economic costs associated with these adverse environmental impacts, the economics literature proves helpful. In a study of acid mine drainage-impaired lakes in rural Ohio, Mishra et al. (2012) find a negative relationship between sulfate levels in impaired lakes and recreational use. Moreover, the literature documenting the structural transition of amenity-rich communities from reliance on extractive industries to tourism-based growth suggests a link between the two: were sulfide-ore copper mining to proceed at the TMM project, it is reasonable to assume that a contraction in tourism and recreation-based economic activity will likely occur, and would increase with the severity of spills, breaches, and/or drainage.

The remaining component of income is the direct effect from those who move away from the region because of the mining and the related direct effect of those deterred from moving to, or retiring in, the region because of the mining (the "in-migration direct income"). To estimate this component, we used as a baseline the 2016 Census Bureau (American Community Survey) total income of the five-township Ely region (Ely, Eagles Nest, Fall Lake, Morse, and Stony River). We projected withdrawal baseline income growth as the sum of per-capita income growth and population growth. Our per-capita income growth projection is the historical per-capita income growth from 1970-2016 for the Arrowhead counties (Headwaters Economics, Economic Profile System 2018). There is a large literature that documents increased population growth in amenities-rich areas, see Rickman and Rickman (2011) and Holmes (2016) for surveys. We adopt the population growth rate from Rickman and Rickman (2011) for counties with USDA amenity rank equal to the average Arrowhead amenities rank (McGranahan 1999). For the TMM counterfactual, we considered two scenarios for in-migration direct income. Polling by Sungur et al. (2014) found that 23% of residents would consider moving from the region in the event that the TMM project were undertaken. This estimate strikes us as high and many of those who would consider moving might not. We therefore consider two scenarios one in which population growth slows to zero and a second in which in-migration population for amenity values declines by 10% over the 20-year period, less than half of the estimate in Sunger et. al. (2013).[14]

3. Results

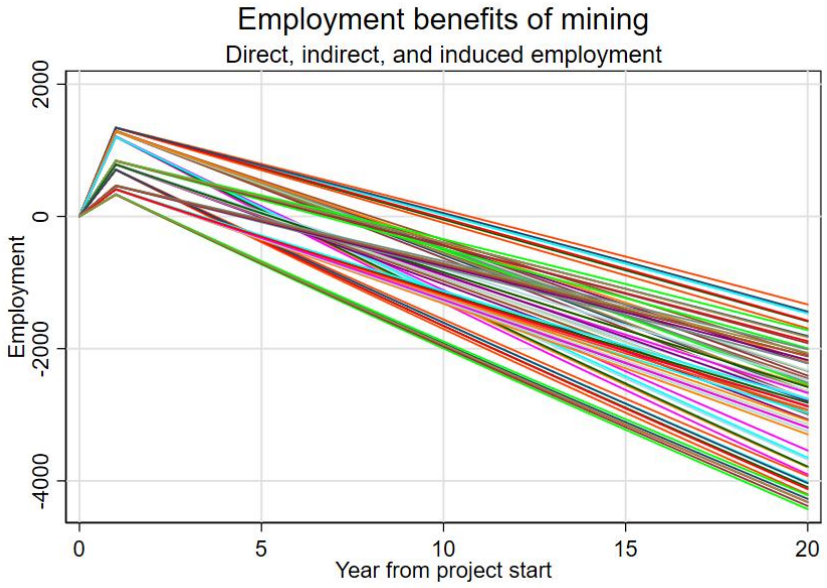
In all, these assumptions generated 72 employment and income paths under the various scenarios. The employment paths are plotted in Figure 2, and the income paths are plotted in Figure 3.

All the scenarios in Figures 2 and 3 show a similar pattern. Initially, mining is economically beneficial because of the new mining jobs, the income they produce, and their spillovers to the local economy. Over time, however, the net effect of the mining jobs erodes because of the growth of productivity in mining, the stagnation or decline of amenity-based in-migration, and the decline in wilderness-based recreation as a result of impacts of mining on the recreation industry. The magnitude and timing of the effect on employment and incomes various across scenarios and assumptions.

[14] In-migrants are treated as bringing income to the economy but are not a business so do not undertake direct hiring; thus there is no direct and indirect employment from this channel. That income is spent in part in the community so it does generate induced employment and income, which are computed in the same way as induced employment and income from mining and recreation .

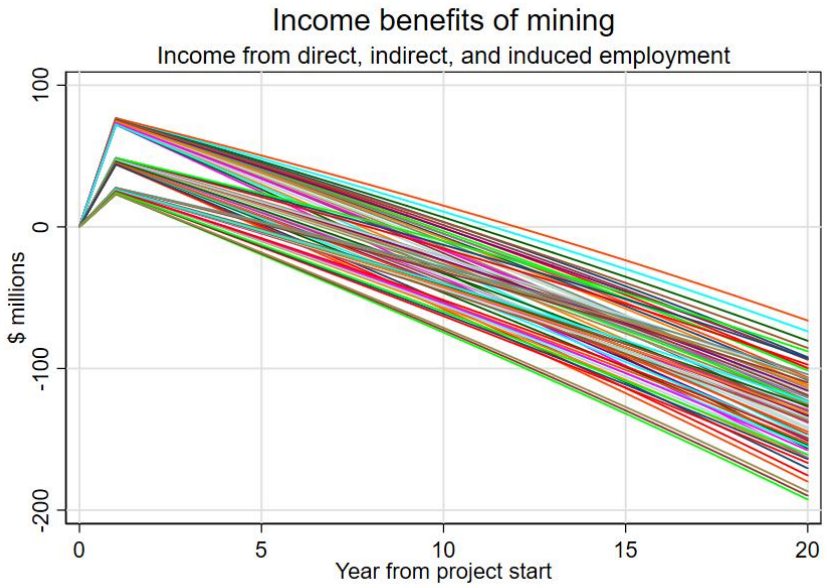
We computed the net present value for each of the income paths, using a 3% real discount rate. A histogram of these net present values is presented in Figure 4. In 89% of the cases, the net present value of the TMM counterfactual is negative, that is, the income benefits of mining are outweighed by the income costs on recreation and in-migration. The cases for which the net present value of the TMM project are positive are those in which mining employment starts at the highest level (650 jobs, despite the 2018 announcement that the project would be scaled back) and impacts to tourism jobs and amenity-based in-migration are low.

Figure 2. Net annual employment effects (direct, indirect, and induced) of the TMM counterfactual over time on the Arrowhead economy. A positive employment value means that, under that scenario, the number of jobs in the TMM mining case exceeds the number of jobs in the no-mining baseline.



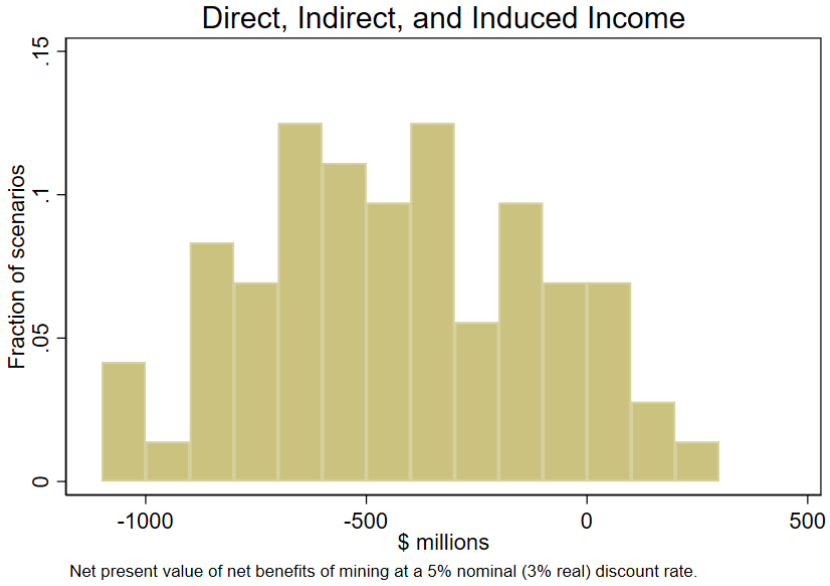
Notes: the horizontal axis denotes time, starting with the commencement of production at the TMM site.
Source: Authors' calculations.

Figure 3. Net annual income effects (direct, indirect, and induced) of withdrawal over time on the Arrowhead economy. A positive income value means that, under that scenario, the annual income in the TMM mining case exceeds the annual income in the no-mining baseline.



Notes: the horizontal axis denotes time, starting with the commencement of production at the TMM site.
Source: Authors' calculations.

Figure 4. Histogram of the net present value (NPV) of income in the 72 scenarios.



Source: Authors' calculations.

4. Our Estimates in the Context of Other Studies

Other studies of rural economic growth and amenities. Multiple studies conclude that outdoor recreation and recreational amenities, especially wilderness amenities, have been the basis for strong and sustainable economic growth in rural communities with those attributes over the past two decades. This literature looks at a variety of measures including income, job growth, population growth in wilderness-abutting regions, willingness-to-pay, and property values. In early influential research, Deller et. al. (2001) studied rural U.S. counties and concluded that "the empirical results provide strong evidence that rural areas which can be characterized as endowed with high levels of key natural resource amenity endowments and overall quality of life experience higher overall levels of growth" (p. 363). Rickman and Rickman (2011) examine population trends and measures of outdoor and recreational amenity in nonmetropolitan counties across the U.S.; they establish a positive relationship between amenity values and population growth. Lorah and Southwick (2003) look at the role of protected federal lands, which hold an intrinsic natural amenity value, on rural population growth in western counties and find that counties with protected federal lands within 50 miles of their center grew approximately 11.7 times faster than nonmetropolitan western counties without protected federal lands within 50 miles of their center. Poudayal et al. (2008) analyze nationwide county-level data on the role of natural resource amenities in attracting retiree in-migration; they find that the percentage of a county under forest, the quantity of high-quality water resources, and the presence of federally protected national parks are all statistically significant drivers of retiree in-migration. Winkler (2007) finds similar demographic trends. McGranahan et. al. (2011) study the underlying mechanism whereby sustainable growth is linked to amenity values and find that this growth has an endogenous element through the channel of entrepreneurs being attracted to rural locations with high outdoor amenity value.

Holmes et. al. (2016) provide a recent survey of the literature on valuation of proximity to wilderness areas. In addition to reviewing estimates of the local economic effects (or "onsite" values) examined here, they include a discussion of "offsite" values on which we have not relied. These "offsite" values include both "use" values (e.g., residential property values; see below) and three so-called "passive use" values: existence value, option value, and bequest value. They argue that these passive use values can be large, a point that is relevant to the withdrawal proposal because they attempt to estimate directly the value of pristine wilderness.

These studies validate the inclusion of in-migration effects that are supported by the withdrawal and are potentially at risk if the withdrawal does not occur. In addition, these studies support a broader

interpretation of the value of the BWCAW and Superior National Forest as an attractor of non-tourism, non-retirement jobs to the area because of the proximate wilderness. This latter category of job is not included in our study, and by excluding such jobs our study is conservative and understates the economic benefits of the withdrawal.

Resource extraction and sustainable growth. The question of resource extraction and economic growth has long been of interest in the economics literature at the country level (e.g., oil export economies), regional level, and local level. Although we are not aware of any recent hard-rock mining studies on the sustainable growth cycle, the boom in nonconventional oil and gas development has stimulated recent research on extractive resource growth cycles.

Jacobsen and Parker (2014) study county-level data for the American West and examine the consequences of oil and gas well drilling arising from the oil price increases of the 1970s and early 1980s. They find "that the boom created substantial short-term economic benefits, but also longer term hardships that persisted in the form of joblessness and depressed local incomes.... In the longer run, after the full boom-and-bust cycle had concluded, we find that local per capita income was about 6% lower than it would have been if the boom had never occurred." (p. 2)

Allcott and Keniston (2017) study US county-level manufacturing data in connection with oil and gas booms and conclude that "while county-level population, employment, wages, and revenue productivity are all procyclical [i.e. all go up in the initial extractive stage], the booms are cancelled out by the busts. By the end of the 1990s, we see no significant remaining long-term effects of the boom and bust cycle of the 1970s and 1980s (p. 5)"

There is also some work on the economic impacts of nonconventional oil and gas extraction, however the scope for dynamic analysis is limited because that development is new and insufficient time has elapsed to observe a full cycle. One set of limited dynamic estimates is provided, however, by Feyrer, Mansur, and Sacerdote (2017). They use local geographic data to provide some estimates of the dynamic effect of nonconventional oil and gas extraction in the 2000s; they find that it has large employment effects, but that those employment effects are transitory at the local level. They only estimate dynamics over the first two years following the initial local extraction shock and find that wage income gains, including direct, indirect, and induced, dissipate by 1/3 within two years (the dissipation is faster if only direct and indirect wages are considered, see their Figure 4). The technology for nonconventional oil and gas extraction has a

shorter life cycle than hard rock mining or conventional oil and gas extraction, but the findings of these studies are all qualitatively consistent with an extractive boom-bust cycle.

These studies are designed to estimate the effects of these booms on counties with average amenity values. Thus these estimates capture the boom-bust effect on resource extraction and related jobs but do not include any special effects that resource extraction disamenities or environmental damage would have on employment and in-migration related to high-amenity regions like the area surrounding the BWCAW. Such effects would exacerbate the boom-bust nature because of the deterioration in environmental conditions and amenity values that would reduce non-mining amenity-related incomes.

Property values and mining disamenities. There is substantial evidence that mining disamenities reduce housing values. In their study of acid mine drainage from coal mining in the Cheat River Watershed of West Virginia, Williamson et al. (2008) find that location near an AMD-impaired stream has an implicit marginal cost of $4,783 on housing, or nearly 12.2% of a home's value. Kim and Harris (1996) examine the broader suite of possible mining disamenities and their effect on property values near a copper mine in Green Valley, AZ and find that parcels closest to the mining site lost 5.74% of their value with homes further away losing 0.66% of their value as well. In their study of sulfide-ore copper mining in the Arrowhead region, Phillips and Alkire (2017) use Kim and Harris' (1996) findings to estimate that the total loss in property value for a single year due to sulfide ore copper mining would be over $508 million (2016 USD), or roughly 1.9% of the total property value of the three Arrowhead region counties.

Phillips and Alkire's (2017) estimate of a decline of 1.9% is in the range of those in related studies. Boxall et al. (2005) examine the impact of oil and gas facilities on rural residential property values in Central Alberta, Canada using hedonic regression methods for property valuation. They find that location within four km. of industry facilities leads to a four to eight percent decrease in property value. Leggett and Bockstael (2000) use a hedonic property model to show that water quality has a significant effect on property values along the Chesapeake Bay, an amenity-rich, non-metropolitan setting with high recreational value. Poor et al. (2007) find a similar result in the Chesapeake Bay watershed examining non-point source pollutants, including suspended solids and nitrogen. In a study of the impact of lake water clarity on New Hampshire lakefront properties, Gibbs et al. (2002) find that water clarity—a measure of the degree of eutrophication—has a significant effect on prices paid for residential properties.

In the case of the proposed withdrawal, these negative effects on housing values would be compounded by the downward pressure on housing values from reduced in-migration or, possibly, out-migration.

Consistent with the boom-bust literature, one could see an initial rise in housing values as mine and associated industry workers buy or rent in the greater Ely area, however that increase would be temporary as mining employment, recreational employment, and in-migration housing demand subsequently decline. By omitting this effect, our analysis is conservative and likely understates the benefits of the proposed withdrawal.

5. Conclusion

We find that, over the 20-year time horizon of the proposed withdrawal, introducing mining in the Superior National Forest is likely to have a negative effect on the regional economy. Our calculations omit some factors, notably the negative effect of mining on real estate values, that would strengthen this conclusion. We reviewed the relevant literature and conclude that our findings are consistent with the literature, most notably the history of boom-bust economies associated with resource extraction that leave the local economy worse off.

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