Prioritizing Environmental Protection: Regulating Sulfide-Ore Mining in the Boundary Waters Canoe Area Wilderness of Northeastern Minnesota

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This paper examines the environmental policy implications and environmental risks of engaging in copper-ore sulfide mining in the Boundary Waters Canoe Area Wilderness of Minnesota. The re-instatement of mining leases in the area within the past year has generated significant controversy within the state. Concern over limiting environmental risk through effective regulation sits at the forefront of the prominent debate taking place at the federal, local, and state levels. Currently, Minnesota is not equipped to properly and effectively regulate these mines for environmental protection. With that goal in mind, this analysis argues that regulations must return to—and continue beyond—the status quo ante, established in 2016, by implementing stricter command and control design & performance standards; mandating severance taxation; establishing research and development programs; improving transparency; addressing information asymmetries; and ensuring liability standards for adequate compensation of incurred costs caused by environmental degradation and displaced industries. Implementation of these policy mechanisms will ensure prioritization of environmental preservation of the Arrowhead region of northeastern Minnesota.

INTRODUCTION

Northeastern Minnesota's sulfide-ore deposits are some of the richest in the world (Forgrave 2017). As society continues to develop technologically, the need for the precious minerals contained in these ores is increasing. This dependence has prompted important discussions over how to best regulate operations of sulfide-ore mines in the face of global climate change and the growing need for environmental protection. Currently, there are hundreds of companies vying to establish sulfide-ore mines in the area (Friends of the Boundary Waters Wilderness 2018). Two of these prospectors in particular are generating controversy in Minnesota. The first is the PolyMet NorthMet mine, located near Hoyt Lakes, Minnesota, about fifty miles from the edge of the Boundary Waters Canoe Area Wilderness (BWCAW). The other is the Twin Metals mine, located just seven miles from the edge of the BWCAW, and only one mile from the edge of the BWCAW watershed (2018). The BWCAW is the United States' most popular wilderness area, a pristine sequence of lakes and streams having remained essentially untouched for time immemorial. Concern of limiting environmental risk through

effective regulation sits at the forefront of the prominent debate taking place at the federal, local, and state levels. Currently, Minnesota is not equipped to properly and effectively regulate these mines for environmental protection. With that goal in mind, this analysis argues that regulations must return to—and continue beyond—the status quo ante, established in 2016, by implementing stricter command and control (CAC) design & performance standards, mandating severance taxation, establishing research and development (R&D) programs, improving transparency, addressing information asymmetries, and ensuring liability standards for adequate compensation of incurred costs caused by environmental degradation and displaced industries. Implementation of these policy mechanisms will ensure prioritization of environmental preservation of the Arrowhead region of northeastern Minnesota.

BACKGROUND

Minnesota's Boundary Waters Canoe Area Wilderness

The Boundary Waters Canoe Area Wilderness is located in northeastern Minnesota along the border with Canada. Illustrated in Figure 1 below, the

Figure 1. BWCAW & SNF. Source: SNFP/USDA (2018).

BWCAW covers the northern third of Superior National Forest (SNF) and is managed by the United States Forest Service (USFS; Superior National Forest Publication/USDA 2018). The BWCAW is a pristine wilderness covering over 1.1 million acres of varied land, including one of the largest expanses of protected boreal forest in North America. The BWCAW landscape is twenty percent water, comprised of over 1,100 lakes, including 1,200 miles of canoe routes, 12 hiking trails, and over 2,000 campsites placed across the land's cliffs, canyons, hills, and rocky shores (Minnesota Pollution Control Agency 2018; Save the Boundary Waters 2016). It is the most heavily used wilderness in the United States, accounting for less than one percent of the acreage of the National Wilderness Preservation System (NWPS), yet representing ten percent of the use (SNFP/USDA 2018).

The untouched state of the area, including the nearby Voyageurs National Park (VNP), Superior National Forest, and Lake Superior are important ecosystems for the region and represent the bulk of environmental tourism to Minnesota. Combined these natural areas contribute an estimated \$531 million to Minnesota's state GDP (Philips 2015). It has been estimated that the value of nature's benefits produced by all federal conservation lands in the United States is more than \$262 billion per year. The BWCAW alone accounts for an estimated \$1.39 billion of this

total, offering incomparable views for visitors hiking the extensive trail system and paddling along the pristine, interconnected waterways (Philips).

The Boundary Waters Canoe Area Wilderness Act was passed on October 21, 1978 by President Jimmy Carter as part of the NWPS, part of the 1964 Wilderness Act, "The intent of the Act was to establish wilderness areas that would remain undeveloped 'for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness'" (SNFP/USDA 2018). When Congress established the act, the USFS was directed to "maintain [the BWCAW's] water quality, protect its fish and wildlife and minimize the environmental impacts associated with mineral development" (Eilperin 2016). In 1978, the act was expanded, prohibiting activities such as mining, logging, and use of motorized vehicles within the BWCAW and in some adjacent lands (SNFP/USDA). The BWCAW receives over 200,000 visitors each year who come to enjoy the area's varied opportunities to canoe, kayak, portage, and camp. Aside from being a national ecotourism hotspot, the BWCAW is a protected habitat for many threatened species, including moose, bear, wolves, loons, ospreys, bald eagles, lynx, river otter, pine martens, warblers, jays, and woodpeckers (Mondale & Rossevelt 2016). The miles of interconnected lakes, streams, and wetlands are home to abundant varieties of fish, including northern pike, bass, trout, walleye, and sturgeon (Save the Boundary Waters 2016).

The Minnesota Pollution Control Agency (MPCA) defines 81 major watersheds in the state, three of which flow into the BWCAW and the nearby Voyageurs National Park. All three of these watersheds—Rainy River - Headwaters, Vermilion River and Rainy River - Rainy Lake watersheds—offer clear indication of where pollution from sulfide mines would flow northward into the BWCAW and VNP, shown in Figure 2 (Garwin 2015). Like the BWCAW, Voyageurs National Park is a very important watershed for northeastern Minnesota, consisting of over 84,000 acres of water, with around 240,000 visitors each year, contributing more than \$19 million dollars to the local economy (Voyageurs

National Park Association). Clearly, water plays an essential role in this region. However, it has been documented that the Arrowhead region, which includes areas of the BWCAW and SNF contains one of largest copper-nickel deposits in the world, holding billions of pounds of these increasingly valuable minerals (Halley 2012). Estimates suggest the mineral resources contained in these sulfide-ores could be valued as high as \$500 billion dollars; though there is some concern that the value will depreciate quickly once mining commences because the deposits will diminish and more become difficult to extract (United States Congressman Tom Emmer 2018; Halley 2012).

Sulfide-Ore Mining

Sulfide-ore extraction is a type of mining that removes metals, such as nickel, lead, zinc, platinum and palladium, gold, silver, and copper from sulfur bearing ores. Sulfide-ore mines can be found across the United States from Montana to New Mexico. As previously stated, one of the key areas of current and future exploration is in the Great Lakes region, specifically the areas surrounding Lake Superior, known as the Duluth Complex (Onello et al. 2016). Thousands of prospectors have flocked to the area because the metals extracted from sulfide-ore mines are important for several large industries that drive our day-to-day operation and consumption. These industries include electronic and plumbing goods, building materials and medical devices, as well as stainless steel and batteries for electric cars (PolyMet Mining). While sulfide mining is an important extractive industry, the waste-to-mineral ratio is fairly high. The United States Geological Survey (USGS) reported that copper accounts for just 60 percent of the processed ore per average yield (Paulu & Babcock). As metals continue to be extracted for steadily growing industries, we can expect the more concentrated ores to be extracted first, lowering the waste-to-mineral ratio and decreasing the economic

Figure 2. Voyageurs Watershed Map & Rainy River Drainage Basin. Source: Voyageurs National Park Association.

feasibility of the projects. The proposed PolyMet mine in northeastern Minnesota has an estimated concentration of 0.28 percent copper and 0.08 percent nickel; ongoing extraction will only reduce the concentration and increase associated risks (PolyMet Mining; Paulu & Babcock). Therefore, it can be expected that the environmental costs will eventually outweigh the economic benefits derived from these extractions.

The sulfide mining process consists of the following stages: exploration, site preparation, mining, beneficiation, waste disposal and reclamation. There are two types of sulfide mines; open pit and underground, with open pit accounting for 83 percent of the mines in the United States, though it should be noted that the controversial Twin Metals mine would operate an underground mine. Both types require extensive drilling and building of infrastructure and result in huge amounts of waste, requiring large amounts of land for waste disposal. Waste is generated both from blasting of waste rock to uncover mineral rock and slag from the beneficiation and smelting processes. Beneficiation is the process of separating the valued minerals from the non-mineralized (valueless) materials. Smelting is

the process of melting down the beneficiation minerals to remove the impurities and separate the metals. This process creates waste products such as slag (iron and silica waste substance), and suspended air particles and gases (sulfur dioxide) which require capture and disposal to prevent leaching into the environment (Paulu & Babcock). Recent technological advances have produced new smelting methods such as the hydrometallurgical and electrowinning process, which is the proposed method of the Minnesota PolyMet mine. As recently as July, 2019, Twin Metals announced that it will use "dry stacking" as a method for waste rock storage of its mine tailings (Seitz 2019). Twin Metals claims the "technique is safer than using dams to hold back ponds full of waste" but questions persist about the environmental damage to air and water quality (STEB 2019). Whichever smelting process is used there remains potential for contamination of the surrounding environmental area from waste products such as waste rock, spent ore, and wastewater. The risk of contamination is quite high within ten miles of the mine, making the concerns particularly relevant for the Twin Metals mine, though experts have expressed trepidation for lands up to 100 miles away (2019; Goepfert & Hausman).

Current State of Affairs: December 2018

The issue of how to effectively regulate sulfide mining is particularly relevant today because of the proposal set forth by Twin Metals Minnesota LLC, a subsidiary of Antofagasta PLC, a Chile-based mining company. In 2013, Twin Metals Minnesota applied for renewal of two expired leases, which were originally granted in 1966 and were set to expire in 2014 (Antofagasta PLC 2016). Twin Metals applied for license to operate a sulfide-ore (non-ferrous) mine located in Ely, Minnesota, just seven miles from the edge of the Boundary Waters (Orrick 2016). Minnesota has a long history of iron ore (ferrous) mining in the region. The Arrowhead region has traditionally depended on mining to support the local economy, and many in the area support continuing that tradition. However, iron ores do not degrade and toxify the same way that sulfide-ores do, and therefore sulfide-ore mines need to be

regulated under different rules and laws and legislators must closely examine the environmental risks when establishing those regulations (Halley 2012).

In 2017, Twin Metals began preparing an operation plan for a sulfide-ore mine in Superior National Forest. The same year, the company commenced evaluation and optimization exercises for a pre-feasibility study of the proposed mine. These are a few of the required first steps to establishing a working mine in Minnesota, as mandated by state and federal regulations. Since then, the issue has become very contentious for Minnesota legislators, politicians, industry representatives, and the general public.

In December 2017, the United States Department of the Interior (DOI) "concluded ...Twin Metals Minnesota, should be reinstated for copper and nickel mining near the border of the Boundary Waters," leading to both leases being officially reinstated in January of 2018 (Moe 2018). This reversed the Obama-era decision, made in December 2016, which rejected the leases after the USFS concluded that a mine there "'posed an inherent potential risk' that threatened 'serious and irreplaceable harm' to the wilderness' and instated a two-year moratorium on mining activities in Superior National Forest located next to the BWCAW and VNP" (Voyageurs National Park Association; Moe). The moratorium covered 234,000 acres out of the 3.9 million acre total that comprises Superior National Forest (SNFP/USDA). In addition to those actions, Obama's DOI authorized an environmental impact study (EIS) on whether to ban mining for twenty years within the SNF (Moe). However, following the renewal of the leases, in January 2018, the Trump Administration scaled back the mandated EIS, which was to examine potential damages incurred to the wilderness caused by reversing the prohibition of mining within SNF. The decision is currently being challenged in the courts by at least three different plaintiffs, representing five environmental groups and nine Minnesota businesses (Marcotty 2018).

ENVIRONMENTAL AND ECONOMIC CONSIDERATIONS

Environmental Risks

Environmental risk is of principal concern when contemplating sulfide-ore mining projects. Environmental contamination to water, air, and soil is at great risk. Negative impacts to fish and wildlife, human health, and complications from acid mine drainage (AMD) and heavy metal contamination (HMC) is also of great concern.

Due to the significance of the BWCAW, VNP, and Superior watersheds in the region, water quality is of particular importance. Specifically, water quality is often negatively impacted by heavy metal contamination. HMC is the process of metals like arsenic, mercury, copper, cadmium, and lead coming into contact with water or soil in a mine. This interaction causes metals to leach out in runoff, infecting ground or surface water and making it unsafe for drinking, in addition to creating uninhabitable aquatic habitats. Unfortunately, the spread of contamination can be very slow, so it is exceedingly difficult to control the affects until long after the environmental damage has occurred (Paulu & Babcock). One study, conducted across the United States, examined 25 mines in which our lack of ability to predict or control these leakages was clearly demonstrated. EISs predicted the sites would not exceed water contamination levels of surface and groundwater set by the United States Environmental Protection Agency (EPA) for each of the 25 mines. However, all of them did exceed those standards in practice (Kuipers et al. 2006). In fact, in 1997, it was determined that over “60 [sulfide-ore] mines or mineral processing plants were on CERCLA’s National Priorities List, indicating contamination so severe that it require[d] federally-funded cleanup” (Halley 2012). Additionally, an estimated 92 percent of United States sulfide-ore copper mines have experienced failures that have impacted water quality, according to the Union of Concerned Scientists (Union of Concerned Scientists 2018). Studies like these highlight a pervasive issue with either our capacity to predict contamination or a lack of

emphasis on planning and environmental impact statements.

Disconcertingly, the process of HMC occurs more rapidly under the conditions of acid mine drainage. AMD is a significant concern for sulfide-ore mining operations because AMD can come from numerous sources including various elements of mining waste, mentioned above, as well as from open pit walls. AMD is an expanded process of acid rock drainage (ARD), “a natural process which occurs when sulfides in rocks become exposed to oxygen and water through weathering... acid leaches from the rock until it is no longer exposed to air and water, or until the sulfides have been removed” (Paulu & Babcock). Excavation from mining sites speeds up sulfide exposure to air and water, producing AMD. This process produces sulfuric acid, which is highly corrosive to metals and tissues and can be extremely dangerous even in moderate concentrations. Notably, AMD may occur during the active life of the mine; however, it may also begin years or decades after the closure of the mine, making it difficult to track and control, as was the case with the Colorado Gold King mine, shown in Figure 3 (Paulu & Babcock). Within the mine site, sulfuric acid will drain and spread into surface water systems through rainwater, severely

Figure 3. Acid Mine Drainage at the Gold King Mine, Colorado. The Gold King mine in Colorado shut down operations in 1925 yet continues to unleash millions of gallons of polluted water today. Source: Ruidoso News Reports (2016).

degrading water quality. Alternatively, it may system in that manner. This drainage creates an environment that is highly caustic to aquatic life and may additionally contaminate drinking water sources. It is estimated that mining has contaminated forty percent of watersheds in the western United States, "In the western U.S., the Forest Service estimates that between 20,000 and 50,000 mines are currently generating acid on Forest Service lands, and that drainage from these mines is impacting between 8,000 and 16,000 kilometers of streams." This contamination causes harm to fish populations, thereby reducing species diversity, as well as poisoning irrigated farmland, which has negative consequences for human health due to bioaccumulation in food supplies (Phillips 2015; Halley 2012; Paulu & Babcock; Onello et al. 2016). Wild rice, one of Minnesota's staple crops is especially sensitive to sulfates compared to other crops (Minnesota Environmental Partnership 2018). All told, it has been estimated that polluted water from sulfide-ore mines operating in northeastern Minnesota could contaminate up to 2.3 million acres of American and Canadian lands (Forgrave 2017).

Soil contamination is another major risk of HMC and AMD in addition to severe water contamination. These processes may cause soils to become more acidic or contain higher concentrations of heavy metals, thereby exacerbating poor water conditions through runoff and affecting ecosystem health. Soil erosion is another concern due to physical disturbance of blasting at the mine site (Paulu & Babcock).

Air conditions may worsen due to dust emissions from blasting, waste disposal, and road construction (Paulu & Babcock). Additionally, if dry stacking is utilized, as proposed by the Twin Metals mine, air conditions are likely to worsen due to fugitive dust. Dry stacking technology compresses waste rock into a "low-moisture, sand-like deposit" stored in the ground (STEB 2019). The act of compressing the rock creates "fugitive dust" which contains potentially reactive materials such as sulfur that can spread quickly over nearby lakes and forests, as well as be carried into populated areas important for tourism during transit from the mining site to the

percolate into the groundwater and enter the water storage site (Kraker 2019). Additionally, Twin Metals plans to store the waste underground close to waters that flow directly into the BWCAW, creating greater risk of water contamination if the pollution is released; the risk of which is exacerbated due to Minnesota's wet climate (Steiz 2019). Once exposed to precipitation, dry stacked tailing can oxidize and leach heavy metals, which may be washed out into nearby soils and bodies of water.

As mentioned, poor air, water, and soil conditions create caustic environments for fish and wildlife and humans. Fish and wildlife experience harmful effects throughout the mining process, beginning with habitat destruction when establishing the mine site and ending with contamination of water and soil systems due to HMC and AMD. It has been documented that fish living within a ten mile zone of an open-pit sulfide mine show negative developmental effects, including underdeveloped or abnormal development of respiratory and reproductive systems. Additionally, there has been some indication that photosynthetic processes in aquatic vegetative species are also being negatively impacted (Steiz 2019). Humans are particularly vulnerable to contaminated water sources containing harmful metals such as lead, arsenic, and mercury. It is heavily documented that such metals can cause long-term damage to the nervous system, kidneys, liver, circulatory system, and gastrointestinal processes, and can negatively affect development in children (Steiz; Onello et al. 2016). Disconcertingly, the EPA reports, "metal mining is consistently the top producer of toxic releases of all US industr[ies], accounting for 47 [percent] in 2000 (3.4 billion) and 27 [percent] (1.17 billion pounds) in 2005 TRI [toxic release inventory] reports" (Paulu & Babcock). Unfortunately, as mentioned, mining conducted within the Rainy-River and Vermilion watersheds will potentially lead to high levels of contamination into BWCAW ecosystems and nearby communities.

It is important to note that there are few limited technologies that attempt to control for environmental damage, particularly for AMD, such as constructed wetland systems, water treatment facilities, and water management and treatment;

however, these methods are severely limited due to the massive scale of correction and extensive cost and time demands. Additionally, even successful implementations of these techniques fail to completely control for AMD leakage. It is evident that technological advancement is required to successfully prevent and treat the effects of AMD.

Economic Risks

Notably, some economists argue that mining is not economically sustainable because excavation companies often fail to “recognize the ‘full costs incurred in mining’ which include the costs of “meeting their environmental responsibilities, and the needs of the future” (Paulu & Babcock).

Environmental responsibilities include cleanup costs from environmental damage (including damages incurred from AMC and HMC) and restoration costs. In 2009, the EPA estimated cleanup costs for 156 sulfide mines could reach between \$20 billion to \$54 billion dollars—an estimate that dwarfs the annual Superfund budget of \$1.1 billion dollars (U.S. EPA 2009). It can surely be assumed that these cost estimates have only increased in the past decade, though the Superfund budget remains the same (U.S. EPA 2018). In New Mexico alone, the cost of cleaning up two large open-pit mines were estimated at over \$800 million (Boulanger & Gorman 2004). It should be noted that these are limited cost estimates and do not account for other types of environmental damage, including damages to human health, wildlife habitat, tourism, and more. Unnervingly, it is often the case that these long-term costs are transferred to the taxpayer, leading to equity concerns.

In Minnesota alone, it is estimated that around 50,000 jobs rely on the fishing industry, which accounts for \$1.5 to \$3 billion of the annual GDP of the state (Paulu & Babcock). In contrast, it is estimated that the two proposed mines themselves will contribute just 3,000 jobs (including direct and indirect jobs) which will account for short-term benefits but will depreciate over time as the minerals are exhausted. The mining industry accounts for just 0.2 percent of Minnesota’s jobs and less than three percent of economic output (Kaul 2018). However, it is estimated that a ban on mining would provide

anywhere from 1,500 to 4,600 additional jobs, contributing up to \$900 million more in income (Phillips, & Alkire 2017). Additionally, conservative estimates predict a loss of \$288 million each year from foregone visitor spending once mines begin operating. Those losses account for 4,490 local jobs, \$76 million in residents’ income, \$31 million in state and local taxes, and \$181 million in business transactions, in addition to as much as \$480 million in lost property value. Clearly, potential losses to the state due to ecosystem damages and loss of ecotourism in the region are staggering and must be considered when evaluating the direct economic benefits derived from mining operations.

POLICY DISCUSSION

The trajectory of recent events, occurring from the 2013 request for lease renewal of Twin Metals mining operations to the current 2018 reinstatement, has driven a series of goal changes at the federal level pertaining to sulfide-ore mining in northeastern Minnesota. In response, policy tools have shifted away from prioritizing environmental preservation of the BWCAW to prioritizing economic development of the region.

Before 2017 and the implementation of current Trump-era policies, both federal and state priorities over sulfide-ore mining were of environmental protection, though, importantly, economic considerations were still relevant and of significant importance (Cama 2017; Halley 2012). However, after the Trump Administration took over federal control, environmental priorities were diminished in favor of economic development; leaving little regard for the preservation of environmental systems in the area. This analysis presumes that sometime in the relatively near future, federal administrative priorities will once again shift. In fact, there are three future scenarios that could be considered. The first is the prioritization of environmental preservation over economic progress. The second is an equal prioritization between environmental considerations and economic growth. The third is a continuance of economic development over environmental conservation. It should be noted that given the recent reports on climate change, it is

most prudent, and arguably most likely, that future legislators and policymakers will prioritize either the first or second scenarios over the third, current scenario.

This paper will analyze the first scenario, which prioritizes environmental protection. As it is, the current status quo of 2018 claims to sit within scenario two; whereby the balance between economic prioritization and environmental protection has been accomplished (Union of Concerned Scientists 2018). Arguably, this is not a factual statement, rather, it could be stated that current legislation is pursuing scenario three. Certainly, there are policy tools available which would more equitably achieve the environmental-economic balance of scenario two. This paper, however, will consider only scenario one; given the dire state of climate change on a global scale. The essential need for federal and state policies to prioritize environmental protection and associated industries over extractive industries has never been greater. Notably, while scenario one should be prioritized, safeguards should be put in place. Such contingencies will be evaluated in this analysis. It may, in fact, be the case that contingency regulations best support scenario two goals, though that will not be determined in the scope of this paper.

Background on Mining Regulations

In 1866, the Federal Mining Act was passed in an attempt regulate the gold rush. Updates to that law were passed in 1872 under the General Mining Law, which established the “rights of citizens to access mineral deposits for exploration, occupation, and purchase” (Paulu & Babcock). The law was next updated in 1920, whereby oil and gas were removed. After passage in 1970, National Environmental Policy Act updates were integrated into the act, while in 1977 the Surface Mining Control and Reclamation Act (SMCRA) was integrated, seeking to combat environmental problems associated with mining, including consequences of AMD. SMCRA requires that certain environmental standards of performance must be met for all mining operations, including conducting an EIS, establishing a reclamation plan, and posting a bond to cover reclamation costs. The 1970s also saw passage of the Clean Air Act (CAA),

the Clean Water Act (CWA), the Safe Drinking Water Act, and Toxic Substances Control Act, while the 1980s and 1990s introduced the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Endangered Species Act environmental standards, all of which must be considered in the permitting process, either mandated by federal or Minnesota state law. Interestingly, mining wastes are excluded from federal regulation under the Resource Conservation and Recovery Act of 1980; currently, the federal government does not regulate mining or mining waste management, leaving regulation up to the states (Halley 2012). In consequence, mining waste is allowed to be dumped into surface water, a potential biohazard when considering effects of AMD. Although a CWA permit is required to operate the mine and CERCLA would be invoked in case of extensive environmental damage, the general lack of oversight and authority over mining activities leaves hazardous gaps in federal capacity to protect valuable environmental resources in the absence of adequate state regulations.

The operation of sulfide mining in Minnesota is regulated by the State Department of Natural Resources (MN DNR), while implementation regulations are defined under the Nonferrous Metallic Mineral Mineland Reclamation Rules established in 1992. In a comprehensive review of the competences and inadequacies of state laws ranging through regulatory scope, review processes, enforcement capacity, program resources, and reporting and official statements, Halley (2012) rates Minnesota’s regulatory authority for non-ferrous mining activities as “fair”. On the state level, Minnesota laws require permits from MN DNR, the Minnesota Board of Water and Soil Resources, as well as the MPCA and mandates EIS for mining operations over 160 acres in size. Compliance with local and federal laws is also mandated as part of the permitting process.

Minnesota’s regulatory scope is detailed and broad; however, in recent years, economic development has been increasingly prioritized over environmental protection. For example, in 2011, the conservative-run state legislature passed a provision that would allow permit applicants, “to write their

own proposed EIS instead of having [MN] DNR write it, and tightening the deadlines for citizen intervention and for permitting decisions” (Halley 2012). This provision was retroactively applied to the PolyMet mine permit application in the same year. At the same time, the permitting and environmental review regulations were streamlined, making the process easier for potential applicants. This demonstrates a general failure to prioritize environmental protection as essential to permit approval. Additionally, weak monitoring capabilities of the state, lax restrictions for use of public funds to finance operations and clean up, unclear and misaligned standards of permit approval, an absence of penalty standards, and a lack of clearly defined standards for MN DNR inspection requirements have generated outcries of public concern, stating a misalignment of state priorities. Though these weaknesses must be addressed if sulfide-ore excavation is to commence, there are several areas in which Minnesota successfully regulates sulfide-ore mining operations, though, importantly, many of these regulations are untried because, as yet, there have been no operating sulfide-ore mines in the state. Successes include detailed technology specifications, especially pertaining to water quality and reclamation standards. Additionally, the State of Minnesota requires several permits to operate a mine, including a mining specific permit from the MN PCA, a CAA permit, and a National Pollutant Discharge Elimination System (NPDES) permit (Halley).

Though mining companies are required to provide “financial assurance” as a damage deposit to fund any necessary cleanup efforts in the case of bankruptcy, in most cases across the United States, taxpayers have ended up bearing the burden of these costs. This occurs due to the difficulty of predicting cleanup costs as well as estimating the magnitude of pollution damage. As has been seen in mine disasters in Montana, New Mexico and British Columbia, the financial assurance provided by the company is often insufficient to cover cleanup costs whereby the burden is shifted onto the state, and subsequently onto the tax base. Additionally, there is potential for assets of bankrupt companies to be awarded to other creditors, whereby the state is left with the entirety of

the financial burden; which has reached up to \$105 million dollars at some sites. One frightening example is that of the Mount Polly copper-gold mine in British Columbia, where the dam that held back toxic mine waste burst, releasing 4.5 million cubic meters of toxic slurry into the pristine lake at the headwaters of the Fraser River. In the aftermath, an expert stated that “there was no tolerable failure rate for mine waste dams, because the cost was too high” (Friends of the Boundary Waters Wilderness). Demonstrably, financial assurance laws are one regulatory area that must be addressed both federally and at the state level.

Current Status Quo

Trump-era politics has been steadily shifting the prioritization of environmental protection in the Arrowhead region to one of economic development. Supporters of sulfide-ore mining argue that operation of the mines will create an economic boost in the region, adding an estimated 3,000 jobs and spurring the economy by an estimated \$200 million (Forgrave 2017). Though, as previously mentioned opponents argue that those economic benefits will be offset by much greater economic losses due to negative impacts on tourism and associated industry growth. Most clearly, the suspension of the comprehensive environmental review requirement, along with the reversal of the prohibition of mining activities in the Superior National Forest supports the shift in federal priorities. However, because these shifts are alarming to a majority of the public, it can be assumed that given the prominent concerns over the effects of climate change and environmental risky behaviors, future administrations will once again prioritize environmental preservation (Pierre-Louis 2018).

Policy Recommendations

This analysis argues that given the exceedingly worsening state of global climate change effects on global and regional ecosystems, it is necessary to prioritize environmental preservation over extractive industries. The bottom line is that the marginal benefits of sulfide-ore extraction do not exceed the marginal costs of environmental degradation and lost economic benefits of industries,

such as ecotourism and fishing, as well as loss of property values that will be negatively impacted by mining operations. This is particularly profound considering the boom-and-bust nature of mining industries and mining companies' tendencies to go bankrupt, leaving the public (and state) to face costs of environmental degradation they did not ask for and cannot afford (Stock 2018; Forgrave 2017).

In order to successfully prioritize environmental protection, future federal legislators and policymakers must return to the status quo ante, established by the Obama Administration. This recurrence includes revoking the reinstated mineral licenses for Twin Metals, including reestablishing a two-year mandatory comprehensive environmental review and EIS of the regional impacts of sulfide-ore mining. Further, the federal government should not only restore the minimum-two year moratorium but confirm the previously proposed twenty-year moratorium on sulfide-ore mining in the Duluth Complex and within the Superior National Forest. Additionally, a prolonged permanent ban should be considered as part of the environmental review.

Whether or not the bans within the BWCAW and SNF are reinstated, Minnesota policymakers must pass legislation that reaches beyond the status quo ante. More robust regulation will ensure effective protection of Minnesota's valuable environmental resources in the case that sulfide-ore mining is permitted in other areas of the state or within SNF in future. Potential policy tools at disposal include mandating severance taxes, establishing R&D programs, improving existing state legislation and regulation, and addressing gaps in transparency and information asymmetries.

Severance taxes are paid when resources are "severed" from the land. Several states have severance tax programs that levy on extractive industries, however, most states, including Minnesota, do not apply these programs to non-ferrous mining activities (Brush 2011). Severance tax revenue is used in a variety of ways throughout the United States, including financing pollution cleanup and conservation programs, supporting public education, and supporting local communities where natural resources are extracted (Alexander 2011). In

2010, Minnesota's severance tax revenue from iron-ore mining reached \$24 million, while charging a tax of \$2.38 per ton of taconite. It has been noted that Minnesota's ferrous mining industry has been declining significantly in recent decades (Kaul 2018). With the abundance of sulfide-ore waiting to be mined throughout the state, Minnesota could expect to see much higher returns if severance taxes were implemented on non-ferrous extraction. If established, the revenue from these taxes should be tied to any potential cleanup or reclamation costs triggered by mine operations.

Next, it is necessary for the government to intervene in the market to correct the inefficiency of innovation. Both the federal and state governments should facilitate new R&D programs for less risky mining operations, as well as innovative, effective, and manageable solutions to address severe environmental pollution from AMD and HMC. This is particularly important when discussing the BWCAW because of the long-term, if not irreversible effects of hazardous sulfide-ore mining operations. One of the roles of the government is to mitigate risk by providing grants for research and information acquisition. In the past, the EPA has both conducted their own studies, as well as funded research for outside parties through grants (Halley 2012). The success of effective future regulation relies fundamentally on the support, both financially and ideologically of government agencies to provide resources that will improve existing legislation. Therefore, these programs must expand and extend beyond the EPA to other federal agencies as well as to the state level.

Similarly, state laws and regulations must be updated and improved to ensure effective and comprehensive legislation that prioritizes protecting our environmental resources. Many of the policy recommendations for state laws outlined below are inspired from Halley's 2012 analysis of Minnesota's sulfide mining regulations. After careful consideration of Minnesota's legislation, it is clear that the state must improve the quality of regulation in regards to environmental protection. Improvements can be made by restructuring command and control (CAC) regulation by

incorporating more stringent performance and design standards, as well as improving liability for damages incurred. Transparency of mining operations and monitoring should be prioritized. Finally, information asymmetries need to be addressed by requiring permittees to provide resources for proper evaluation of operating practices.

Improved state regulation can begin by reassessing CAC design standards of permit applications. Specifically, the use of public funds in assisting any project that has not completed and passed a comprehensive environmental review should be restricted, in addition to requiring that environmental assessment be completed by the state (and funded by the applicant). Likewise, the failure to define that the "goal of reclamation should be to return the area to environmental functionality, not to find a balance with economic development or simply "do one's best" must be reexamined (Halley 2012). Rather, it should be a requirement that a polluted area would be fully capable of returning to environmental functionality and not require "perpetual care," as is mandated under a Michigan law (Friends of the Boundary Waters Wilderness). Moreover, there should be a zero-tolerance limit on pollution; meaning failure to comply with all applicable state and federal standards of operation should be grounds for permit revocation until the deficiency or violation has been corrected. Undoubtedly, increasingly stringent laws are required to ensure compliance in faithfully and comprehensively addressing every potential impact identified in the environmental assessment. Applications should be approved only when it has been positively determined "that all application standards set forth in the rules are met," and that each responsible agency is bound to enforce those standards (Halley 2012). Finally, technology based standards should be examined as research and development continue to improve through government funded programs.

Next, strict liability should be maintained and improved upon by requiring potential polluters to assume liability in the case of severe environmental harm. For instance, Minnesota should look to the example of New Mexico, which raised the financial assurance on two dangerous mines to \$400 million

each (Friends of the Boundary Waters Wilderness). Similarly, regulations for compensation costs should be improved by mandating compensation for damage to lost livelihoods, as well as adverse effects on the local economy and upon property values. Finally, proof of adequate ability to cover long-term recovery and cleanup costs should be required before permit approval.

Improving the transparency of mining operations and state monitoring procedures is necessary. First, the state must establish superior standards for agency cooperation and coordination within the permitting, monitoring, and enforcement processes. Next, the state must require robust transparency requirements for both the monitoring agencies, as well as the mining operations themselves (Halley 2012). Minnesota should explore legislation similar to Wisconsin's "Prove It First" law of 1997, which requires that, "before opening a mine, a company must be able to point to a similar mine to what it is proposing that a) has operated for [ten] years without polluting and b) has been closed for [ten] years without polluting" (Friends of the Boundary Waters Wilderness). Severe transparency laws such as this ensure both the public and state are aware of the consequences of proceeding with sulfide-ore operations, allowing proper weight to both benefits and costs of operations.

Finally, information asymmetries should be addressed by shifting the burden to private mining subsidiaries and by establishing more robust requirements for feasible contingency plans and management strategies. Most decisively, permittees should be prohibited from self-monitoring, as is currently the case (Halley 2012). This is a severe omission by the state and must be addressed before sulfide-ore operations are allowed to commence. Rather, mining companies should undertake the risk of operation by funding improvements to the state's capacity to conduct independent monitoring under strictly regulated standards and time frames for any active mine or reclamation site. Such an undertaking will relieve the tax base of a debilitating and unjust burden and ensure good and proper evaluation of sulfide-ore mining operations.

CONCLUSION

The Boundary Waters Canoe Area Wilderness of northeastern Minnesota is an ecologically important watershed for the local region and contributes significantly to the local and state economies. The untouched state of the area is estimated to contribute around \$1.39 billion to the state, offering incomparable views for visitors hiking the extensive trail system and paddling along the pristine, interconnected waterways (Phillips 2015).

The threat of sulfide-ore mining in the region is significant, both due to potential economic impacts and the extremely high risk of environmental degradation caused by heavy metal contamination and acid mine drainage from mining operations. Not only are the ecologically important watersheds at risk, but the risk of ecosystem damage for aquatic and terrestrial wildlife is extensive. Additionally, human health may be affected due to leaching of sulfuric acid into our air, water, and soil systems (Onello, et al. 2016). Notably, the chances of safe operation of sulfide-ore mines remain disconcertingly low. Paired with relatively lax state and federal regulation standards and minimal (and untested) requirements for reclamation and cleanup procedures, weak community compensation for economic and ecological costs, and inadequate monitoring techniques; risk of severe environmental degradation is high.

Unfortunately, the current status quo prioritizes economic development over environmental consideration. Fortunately, we can reasonably expect these priorities to return, at least, to the prior status quo of 2016. It is argued in this paper that future administrations, legislators, and policymakers should strive to exceed the established status quo ante and establish more stringent environmental protections. Given the increasingly grim outlook of the effects of global climate change, policymakers should prioritize environmental conservancy over the short-term benefits derived from extractive industries. To successfully achieve such a progressive environmental agenda, first steps such as reestablishing past moratoriums and passing permanent bans should be considered. Additionally, the federal government should mandate

comprehensive environmental reviews. Further, policymakers should consider policy tools such as passing stricter command and control design & performance standards, implementing severance taxation, improving transparency, and establishing research and development grant programs. Finally, information asymmetries should be reduced, while strict liability standards must be improved upon to ensure adequate compensation for incurred costs caused by environmental degradation and displaced industries. Implementation of these policy tools will combine to act as safeguards, ensuring prioritization of environmental protection interests in the event that sulfide-ore mining operations commence in the state of Minnesota.

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