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Risks and costs to human health of sulfide-ore mining near the Boundary Waters Canoe Area Wilderness

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ABSTRACT

Sulfide-ore copper nickel (SOCN) mining is being considered in water-rich Minnesota. Given pollution resulting from SOCN mining elsewhere, careful scrutiny is necessary examining the risks associated. Health considerations of mining within the Rainy River Watershed, the geographic region at the headwaters of the Boundary Waters Canoe Area Wilderness (BWCAW), Ontario's Quetico Park (Quetico), and Voyageurs National Park (VNP) are examined. This discussion considers toxins released from SOCN mining, examines data regarding degradation of water quality and deleterious environmental impact from SOCN mining elsewhere, considers the most vulnerable populations, and recognizes the broader effects to public health as well as benefits of existing wilderness. Recent federal decisions to reinstate mineral leases and abort the environmental assessment process have placed this unique and irreplaceable region of our country at substantial risk. The overall health and wellness of this region will very likely be negatively affected by SOCN mining, and economic costs will predictably outweigh benefits. In addition, negative impacts on water, fish and wild rice will likely degrade nutritional and tribal resources resulting in violation of usufructuary rights of tribal communities.

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Introduction

Minnesota is known as “the land of 10,000 lakes.” The name comes from the native Ojibway (or Anishinaabe) language and translates to “land of sky-blue waters.” The state lies at the head of three continental watersheds and shares its northeastern border with Lake Superior, which is estimated to contain 10 percent of the planet’s freshwater (Minnesota Water Facts 2010). What Saudi Arabia is to oil, Minnesota is to freshwater. The Duluth Complex is a mineral deposit containing copper, nickel, and precious metals that lies within the Lake Superior and Hudson Bay Watersheds (NorthMet Mining Project and Land Exchange 2015). Active SOCN (also referred to as hard rock) mining is now being pursued in northern Minnesota, an area without any prior SOCN mining.

In the current global climate where lack of access to freshwater is causing crises in many countries, decision-makers must carefully weigh damaging one resource, in the effort to extract another. As the One Health movement has articulated, human health, animal health, and ecosystem health are inextricably linked (One Health Initiative 2018). It is imperative that this linkage is fully appreciated as the risks and benefits of industry proposals with potential large-scale detriments to ecosystem and human health are examined. Current decisions regarding SOCN mining in northern Minnesota should be examined through this ecological lens. Proponents argue that precious metals are necessary to support modern life. But it is critical that careful examination and scientific scrutiny be applied in assessing the potential risks and costs of extracting these heavy metals from this pristine, fragile geographical location.

The BWCAW is the most visited wilderness area in the country with over 155,000 individuals annually paddling, camping, and fishing in this wilderness (Boundary Waters Canoe Area Wilderness 2018). Referred to as the “crown jewel” of Minnesota, it is one of the rare places on earth where travelers can drink water directly from lakes while traveling by canoe or kayak. Foreign-owned Twin Metals/Antofagasta is planning SOCN mines on public lands adjacent to the BWCAW along the Kawishiwi River and Birch Lake. Any resulting toxic mine leachate would flow into the Kawishiwi River or Birch Lake and be carried directly into the BWCAW, and eventually into Quetico and Voyageurs National Park (Figure 1). Because of this threat, the American Rivers Association listed the Kawishiwi River as the nation’s third most endangered river (America’s Most Endangered Rivers of 2018 2018).

Discussion

Effects of SOCN mining

SOCN mining has an extensive history of surface and ground water pollution and creation of acid mine drainage (AMD). Kuipers *et al.* (2006) studied twenty-five operating hard rock mines across the United States and their respective Environmental Impact Statements (EIS’s) submitted before operation commenced. All of the mines predicted compliance with water quality standards within their EIS’s; however, pollution from 85 percent of the mines near surface water (Table 1) exceeded water quality standards and pollution from 93 percent of the mines near ground water (Table 2) exceeded water quality standards. Of the sites that developed AMD, 89 percent had inaccurately predicted that they would not create AMD. Most of these contaminants to surface or ground water included the toxic heavy metals mercury, lead, arsenic, cadmium, copper, nickel, and zinc as well as sulfates (Kuipers *et al.* 2006). Earthworks studied fourteen currently operating copper mines representing 89 percent of United States copper production in 2010 (Gestrung 2012). Each of these mines had been operating for more than five years. One hundred percent of the mines had pipeline spills or other accidental releases. In 92 percent of the mines, water collection and treatment systems failed to control contaminated mine seepage, resulting in significant water quality impact including AMD (Table 3). Many of these mines are located in the arid southwest, and the authors state that more significant impacts could be expected at mines in wetter climates. Dr. Tom Myers studied the hydrology of surface and groundwater flow through

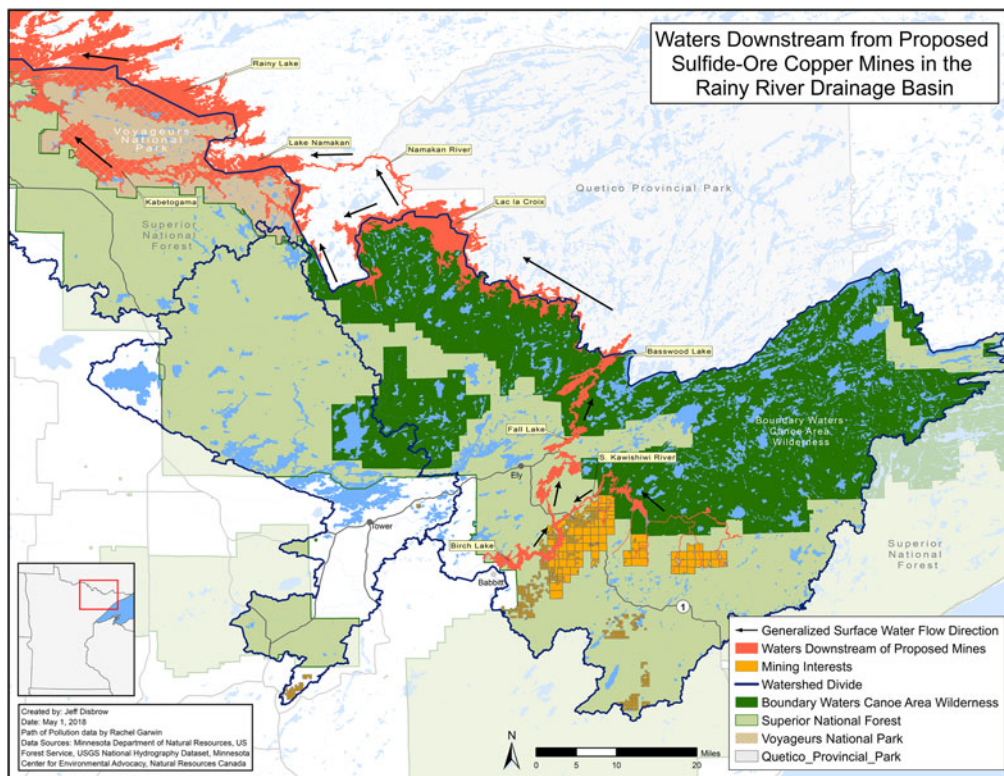


Figure 1. Path of pollution from SOCN (sulfide-ore copper nickel) mining. (Allowed permission for use by Jeff Disbrow and Rachel Garwin, as indicated on image. Color reproduction would be preferable.).

Table 1. Surface water quality impacts for mines with close proximity to surface water and elevated acid drainage potential compared to surface water impacts for all case study mines (Kuipers et al. 2006).

	# mines	% with impact to surface water	% with exceedances of standards in surface water	% with exceedances that predicted no exceedances
Mines with close proximity to surface water and elevated acid drainage and contaminant leaching potential	13	92% (12/13)	85% (11/13)	91% (10/11)
All case study mines	25	64% (16/25)	60% (15/25)	73% (11/15)

the Rainy River Headwaters Watershed near the current SOCN mining leases adjacent to the BWCAW. He stated: “If mineral deposits in the Rainy Headwaters are developed, it is not a question of whether, but when a leak will occur that will have major impacts on the water quality of the Boundary Waters Canoe Area Wilderness” (Myers 2014).

Toxins of concern and windows of vulnerability

The World Health Organization lists the ten environmental toxins with greatest concern to human health (Ten chemicals of major public health concern 2016). SOCN mining

Table 2. Groundwater quality impacts for mines with close proximity to groundwater and elevated acid drainage potential compared to groundwater impacts for all case study mines (Kuipers et al. 2006).

	# mines	% with impact to groundwater or seeps	% with exceedances of standards in groundwater or seeps	% with exceedances that predicted no exceedances
Mines with close proximity to groundwater and elevated acid drainage and contaminant leaching potential	15	93% (14/15)	93% (14/15)	86% (12/14)
All case study mines	25	68% (17/25)	68% (17/25)	52% (13/25)

Table 3. Data for 14 copper porphyry mines operating in the U.S. (Earthworks 2012).

# copper porphyry mines studied	Mines with pipeline spills or other accidental releases	Mines where water collection and treatment systems failed to control contaminated mine seepage, resulting in significant water quality impacts	Mines where partial tailing impoundment failures have occurred	Mines where tailings spills have occurred
14	14 (100%)	13 (92%)	4 (28%)	9 (64%)

releases six of these including mercury, lead, arsenic, particulate air pollution, asbestos, and cadmium. These toxins have harmful effects to human health including cancer, lung disease, heart disease, and neurodevelopmental disease (Ten chemicals of major public health concern 2016). SOCN mining also releases sulfates that, when present within the ecosystem, promote sulfate-reducing bacteria in sediments to methylate mercury already present in the environment. This produces the more bio-toxic form of mercury, methylmercury, a known neurodevelopmental toxin. SOCN mining differs significantly from iron-ore (taconite or ferrous) mining which has been practiced for decades within this region (Onello *et al.* 2016). Given the geology and chemistry of sulfide-ore containing rock, once this ore is extracted and comes in contact with moisture and atmospheric oxygen, toxic AMD results (Jacobs *et al.* 2013). Mining operations excavate and crush millions of tons of rock to acquire a fractional amount of the desired metals. Once extracted, the inevitable resulting process cannot be reversed. Waste rock tailings continue to leach AMD, which is expected to continue for centuries and inevitably make its way into surrounding water, soil, fish, wildlife, and humans.

Methylmercury, lead, arsenic, and other heavy metals are often by-products of SOCN mining. Once these metals have been released into the environment, food, and water supply, they have a strong affinity for neural tissues, the brain in particular. This is due to heavy metals' high affinity for fatty substances. Brain tissue is rich in fat, as are the species of fish in this region most known to be repositories for methylmercury (e.g., walleye pike, northern pike, lake trout, bass). The adverse health effects of heavy metals in human nerve and brain tissue have greater influence during certain stages of human development. While still *in utero*, the fetus is at a triple disadvantage in absorption of heavy metals to which the mother is exposed. The placenta, which prevents many substances in the blood from reaching the fetus, is not able to filter out heavy metals, and

thus, these compounds reach the fetal circulation. In addition, the blood–brain barrier, which keeps older children and adults somewhat protected from toxins in the bloodstream entering the brain tissue, is not fully formed until approximately age two to three years. Therefore, from the period of conception through the first few years of life, the child’s vulnerability to exposures is increased (Kliegman *et al.* 2016). Lastly, once heavy metals or other toxins reach nerve and brain tissue, the amount of damage done is proportional to the rate of growth and cell division of the tissues. The brain doubles in size in the first year of life, and by age three, it grows to approximately 80 percent of its adult volume. This makes the brains of young children extremely vulnerable to heavy metal neurotoxins.

As discussed in recent medical literature, toxins such as methylmercury and lead are some of the known causes of an increased prevalence of neurodevelopmental disorders (Grandjean and Landrigan 2014). These diagnoses often become manifested through preschool and early school ages and include dyslexia and other learning disorders, autism, cerebral palsy, intellectual disability (low IQ), and attention deficit hyperactivity disorder (Gorini *et al.* 2014). The effects of heavy metal toxicity can continue into later life. During late adolescence and early adulthood, proven outcomes from early-life lead exposure include low academic achievement, high rates of educational and work disability, and increased rates of aggression and criminal behavior. In addition, each of the early childhood conditions noted above can increase the risk of depression and anxiety disorders. In older adulthood, early-life lead and methylmercury exposure has been shown to cause higher rates of early cognitive decline, dementia, and other neurodegenerative processes (Muller *et al.* 2018). Toxicity and effects of heavy metals can affect individuals at any age; however, the period of vulnerability is greatest early in life. The resulting disorders are not reversible, are costly to society, and can have life-long consequences.

Toxic mercury and lead exposures are already a problem in Minnesota. The Minnesota Department of Health (MDH) released a study in 2011 which found that 10 percent of the newborns in the Minnesota portion of the Lake Superior basin had elevated blood mercury levels, with some exceeding the EPA toxic level (McCann 2011). There are no safe levels of lead; yet alarmingly, the *Journal of Pediatrics* reported that 10.3 percent of Minnesota children under six years of age had elevated blood lead levels (McClure *et al.* 2016). This toxic burden will be increased by releases of these heavy metals into surface and ground water and by the AMD which will occur with SOCN mining.

The cost for healthcare, special education, and loss of productivity resulting from potential human health impairments related to these exposures is important to consider. In a region that currently has an inadequate number of mental health professionals and facilities to meet even its current needs, consideration must also be given to not only the cost, but the realistic capability of increasing the number of mental health providers. A comprehensive economic assessment of cost of toxicity from AMD and heavy metals is beyond the scope of this discussion; however, we can look at the cost of methylmercury exposure as an example. The loss of productivity from methylmercury toxicity has been estimated to be \$8.7 billion annually in the United States (Bose-O’Reilly *et al.* 2010). Even a relatively “minor” impact on brain development can lead to substantial

reduction in the ability to function, affecting an individual's earning capacity. Each IQ point loss has been found to decrease average lifetime earning capacity by \$18,000. A reduction in IQ from 100 to 90 (still within the normal range) is estimated to cause \$180,000 lifetime reduction in earning capacity (Grandjean and Landrigan 2014). Long-term healthcare and educational costs of insidious toxicity to the local and regional population must be considered.

Cultural considerations

Local native Ojibway people migrated west on the Great Lakes to find “where the food grows on water” and regard wild rice (Ma-no'-min) as a gift to them from the Creator (Benton-Banai 2010). Approximately five and a half million acres of land comprising the Arrowhead Region in northern Minnesota, including the BWCAW, was ceded to the United States Government by the Treaty of 1854. Wild rice is harvested from many of these waters. With the 1854 Treaty, the Lake Superior Bands of Ojibway retain the usufructuary rights (use and enjoyment rights) to hunt, fish, and gather on these lands. Engaging in treaty-protected activities is important for this regions' Ojibway communities, and existing data support the connection between participation in traditional practices and improved health (Sasakamoose *et al.* 2017). In addition to manoomin's cultural and spiritual importance, it is a nutritionally advantageous grain, with a favorable cardioprotective profile offering omega-3 fats, B vitamins, and desirable levels of protein, fiber, carbohydrate, and total fat (Timm and Slavin 2014).

Aqueous sulfates released into the ecosystem from anthropogenic sources like SOCN mining are converted to sulfides which are toxic to wild rice growth. Wild rice does not grow in waters with high levels of sulfate (Myrbo *et al.* 2017). Already, wild rice harvests from natural rice stands have been significantly diminished by sulfate discharges from existing ferrous mining operations (Coleman 2018). Recognizing this, all efforts must be taken to avoid further degradation or elimination of an accessible, health-promoting food source such as manoomin. Assurance of healthy food sources from hunting, fishing, and harvesting wild rice is essential to support tribal community health and to avoid abrogation of usufructuary treaty rights.

Concerns regarding air quality

Air quality will be affected by SOCN mining. Mining operations create fine particulates that are difficult to contain and are known to cause lung and heart disease at low levels, even below EPA standards (Franklin *et al.* 2015; Shi *et al.* 2016). The Duluth Complex ore body is known to contain elongated mineral fibers that bear similarities to asbestos and are active in animal models for lung cancer (Cook *et al.* 2016). The Taconite Worker's Health Study, conducted by the University of Minnesota, showed increased risk of mesothelioma (over 200 percent), lung cancer (20 percent), and heart disease (11 percent) among local miners (Finnegan and Mandel 2014). A study to detect airborne fibers in the region found that the highest levels occurred when winds were blowing toward the town of Ely from the northeastern Iron Range (i.e., from the taconite mines), and the lowest levels occurred during a miners' strike (Ring 2014). Mining in

the Superior National Forest adjacent to the BWCAW would predictably cause degradation of the air quality in the region, affecting miners, members of nearby communities, and visitors to the BWCAW. As with other toxicity discussed, the harm would be insidious, potentially causing disease years after exposures occurred. In addition to creating fine and asbestos-like air particulates directly from mining operations, mining will further affect air quality because of emissions from offsite power generation needed to sustain a large-scale mining operation. The BWCAW, designated a Class 1 Airspace, is already degraded by regional haze from coal-fired power generation and other industry blowing into the region. Increasing the industrial operations at the gateway to this wilderness will only increase the area's burden of air pollution (Hemphill 2017).

Effects to social determinants of health in region

Research recognizes that at least 60 percent of human health is determined by environmental and social conditions and behaviors, referred to in public health as the social determinants of health (Social determinants of health: Know what affects health 2018). The value of the BWCAW, what it provides to the region and beyond, and an assessment of the risks and costs of disrupting this sensitive and unique region must be considered. Currently, the community of Ely and surrounding townships serves as the western gateway to this most visited national wilderness. The pristine state of the wilderness is necessary to attract visitors coming in to experience the BWCAW and additionally supports local resorts, outfitting companies, restaurants, grocery stores, and many other local businesses. Beyond the local economy, a robust recreational industry has developed regionally, largely due to the proximity of the BWCAW. Throughout the upper Midwest, this industry contributes to a stable tax base, jobs in a range of sectors, and the attraction and retention of talent and wealth regionally (Phillips and Alkire 2017). Senator Gaylord Nelson, the former Senator from Wisconsin who founded Earth Day, stated the following: "The wealth of the nation is its air, water, soil, forests, minerals, rivers, lakes, oceans, scenic beauty, wildlife habitats and biodiversity.... In short, that's all there is. That's the whole economy." Economists have worked to infer the financial value of these benefits derived from wilderness that Senator Nelson intuitively understood. Esposito *et al.* (2011) estimated the value of nature's benefits or "ecosystem services" provided by the BWCAW region, including Superior National Forest and Voyageurs National Park, and contributes \$1.39 billion to the total value calculated for federal conservation lands in the United States. Recent analysis by Harvard University economists in August 2018 also conclude that "introducing mining in the Superior National Forest is very likely to have a negative effect on the regional economy" (Stock and Bradt 2018).

In addition to the economic benefits and stability provided by wilderness-related usage, the BWCAW serves as an irreplaceable source of mental and spiritual health, healing and rehabilitation for local communities and visitors. Consideration must be given to the loss of wellness that will result if communities around the BWCAW were to transition from serving as the gateway to pristine wilderness to becoming a gateway to large industrial mine sites. As Figure 2 illustrates, the proposed SOCN mining locations abut surrounding wilderness. Consideration must also be given to inevitable noise



Figure 2. Aerial photograph of affected wilderness area at headwaters of BWCAW. (Allowed permission for use by Brad Carlson Photography, as indicated on image. Color reproduction would be preferable.).

pollution that will result from mining operations and the loss of serenity that this wilderness provides local residents as well as all visitors. Most individuals who travel to the BWCAW do so to appreciate the peace, serenity, and nature as well as the overall health and wellness that result. In addition, a portion of the population uses this region for significant mental health disabilities. Many businesses incorporate trips into BWCAW and surrounding area to aid in treating individuals with mental health conditions including the following: veterans and other traumatized individuals suffering from post-traumatic stress disorder; youth with emotional, behavioral, substance use, and developmental disorders; and physically or developmentally challenged individuals. The BWCAW is more accessible than many other wilderness areas in the country and has provided transformative experiences for countless individuals who often have limited wilderness exposure. Degradation of the wilderness will erode these valuable programs.

Mineral leases and federal regulation

The Twin Metals Mining Company (TMM) has two mineral leases with the Bureau of Land Management (BLM), MNES1352 and MNES 1353 for mining in the Superior National Forest in the watershed of the BWCA. These leases were issued in 1966 for an initial term of 20 years with the possibility of three ten-year renewals. The BLM, with the consent of the surface management agency, the U.S. Forest Service (USFS), renewed the leases in 1986 and 2004. These leases expired on December 31, 2013. TMM applied for a third renewal in 2013. BLM requested that the USFS decide whether it would consent to the renewal of the leases, as consent of the USFS is required by law for mineral

leases in the Superior National Forest. After a lengthy period of consideration, public consultation, and review of the relevant science, the USFS withheld consent for renewal of the leases on December 14, 2016. Chief Tidwell wrote: “I find it unacceptable the inherent potential risk that development of a regionally-untested copper nickel sulfide ore mine within the same watershed as the BWCAW might cause serious and irreplaceable harm to this unique, iconic, and irreplaceable wilderness area.” Because the BLM is required by law to have USFS consent to renew these leases, the BLM denied the lease renewals.

Shortly after the decision to deny the lease renewals, the USFS submitted an application to the BLM and the Secretary of the Interior to withdraw key portions of the BWCAW Watershed from future federal mining leases. The application set in motion a process to put on hold new mineral leasing and related actions for a period of two years while the Department of the Interior, the BLM, and the USFS study whether to withdraw the area from mining consideration for 20 years. The environmental assessment period began, initially with intent to produce an Environmental Impact Statement (EIS), but with eventual downgrade to a less robust Environmental Assessment (EA).

However, on May 2, 2018, the BLM reinstated these expired mining leases and reinstated applications, previously denied, to renew these expired leases. On September 6, 2018, the Trump administration canceled the mineral withdrawal as well as the environmental assessment underway. The BLM then released an EA on December 20, 2018, supporting the renewal of federal mineral leases 1352 AND 1353, again opening the door for SOCM mining at the headwaters of the BWCAW.

Voices of health professionals

Because of the toxic reality of this industry and the potential adverse effects to human health and wellness in the region, there has been an unprecedented voice of concern raised by health professionals and health advocates in response to SOCN mining. Since 2014, in response to the first EIS submitted for proposed SOCN mining in Minnesota, many health professional organizations have submitted letters outlining health concerns. These organizations include the Minnesota Academy of Family Physicians (MAFP), Minnesota Medical Association, Minnesota Nurses Association, Minnesota Public Health Association, along with hundreds of individual providers and nonprofit groups with ties to human health. The consensus by all of these groups is that a comprehensive Health Impact Assessment (HIA) should be included as part of an EIS for SOCN mining proposals. In addition to this, the Minnesota Academy of Family Physicians (the largest medical specialty organization in Minnesota) passed a resolution in 2016 that was brought to the Minnesota Environmental Quality Board (MNEQB) as a petition for rulemaking to require that an HIA be completed for all future nonferrous metallic minerals mining projects that would require an EIS or Environmental Assessment Worksheet (EAW) in Minnesota. This petition is currently being considered by the MNEQB. The concern of medical professionals within Minnesota echo those of many others advocating for HIA and a “Health in all Policies” approach to projects affecting public health (Browne and Rutherford 2017; Burke *et al.* 2017; Cole *et al.* 2004; Dannenberg *et al.* 2006; Quigley and Taylor 2004). A thoughtful and inclusive HIA can

provide the opportunity to plan for and protect human health before large policy decisions are made or permits are allowed.

Conclusion

SOCN mining poses a very real and present threat to not only the most visited wilderness area in the country, the BWCAW, but to human health and wellness in this region. Recently reinstated mining leases and cessation of adequate environmental assessment further amplify this threat. The recently released EA does not even mention, much less analyze, the serious potential impacts to human health that have been voiced for years by health professionals and scientists as discussed in detail above. Given this, Twin Metal's current lease renewal application should be denied, with any future applications mandating a much more rigorous environmental assessment.

Health professionals understand the inextricable link between human, animal, and ecosystem health. This link must be scientifically scrutinized by our regulatory agencies with industry such as SOCN mining, so that both ecosystem and human health are not irreversibly compromised. Many voices have called for a "Health in all Policies" approach for critical decisions being made by federal and state agencies. It is imperative that decisions affecting the Rainy River Watershed on the lands bordering the BWCAW employ a "best practices" approach in order to safeguard the health and wellness of this region. Citizens and public health professionals must insist that a full EIS be done for a toxic industry such as SOCN mining and that this EIS includes a comprehensive and robust HIA. It is essential that assessment includes not only the potential deleterious human health effects of SOCN mining in this water-rich area, but also includes an assessment of the inherent health benefits of preserving the region's natural resources. Only then will the risks and costs of what will be lost with the development of a SOCN mine at the headwaters of the BWCAW be fully evident. Protection is critical for this sensitive, unique, and irreplaceable region of our country and the people who live and visit the BWCAW area. It is critical that government decisions protect human and ecological health. Minnesota's invaluable resource, water, along with the health and wellness of future generations of this region must not be irreversibly compromised.

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References

America's Most Endangered Rivers of 2018. 2018. Am Rivers. Available: <https://www.american-rivers.org/threats-solutions/americas-most-endangered-rivers-of-2018/> [accessed 23 April 2018].

- Benton-Banai E. 2010. *The Mishomis Book: The Voice of the Ojibway*. University of Minnesota Press, Minneapolis, MN.
- Bose-O'Reilly S, McCarty KM, Steckling N, *et al.* 2010. Mercury exposure and children's health. *Curr Probl Pediatr Adolesc Health Care* 40:186–215.
- Boundary Waters Canoe Area Wilderness: Trip planning guide. 2018.
- Browne GR, and Rutherford ID. 2017. The case for “Environment in All Policies”: Lessons from the “Health in All Policies” approach in public health. *Environ Health Perspect* 125:149–54.
- Burke TA, Cascio WE, Costa DL, *et al.* 2017. Rethinking environmental protection: Meeting the challenges of a changing world. *Environ Health Perspect* 125:A43–9.
- Cole BL, Wilhelm M, Long PV, *et al.* 2004. Prospects for health impact assessment in the United States: New and improved environmental impact assessment or something different? *J Health Polit Policy Law* 29:1153–86.
- Coleman J. 2018. Iron Mining in Minnesota: A Difficult Time for Wild Rice. *A Chronicle of the Lake Superior Ojibwe, Mazina'igan*.
- Cook PM, Swintek J, Dawson TD, *et al.* 2016. Quantitative structure-mesothelioma potency model optimization for complex mixtures of elongated particles in rat pleura: A retrospective study. *J Toxicol Environ Health B Crit Rev* 19:266–88.
- Dannenberg AL, Bhatia R, Cole BL, *et al.* 2006. Growing the field of health impact assessment in the United States: An agenda for research and practice. *Am J Public Health* 96:262–70.
- Espósito V, Phillips S, Boumans R, *et al.* 2011. Climate change and ecosystem services: The contribution of and impacts on federal public lands in the United States. In: *Science and Stewardship to protect and sustain Wilderness Values: Ninth World Wilderness Congress Symposium*; November 6–13, 2009, Merida, Yucatan, Mexico. Proceedings. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO, pp. 155–164.
- Finnegan Jr. JR, and Mandel JH. 2014. *Taconite Workers Health Study: Final Report to Minnesota Legislature*.
- Franklin BA, Brook R, Arden Pope C. 2015. Air pollution and cardiovascular disease. *Curr Probl Cardiol* 40:207–38.
- Gestring B. 2012. *U.S. Copper Porphyry Mines: The track record of water quality impacts resulting from pipeline spills, tailings failures and water collection and treatment failures*. EARTHWORKS, July 2012 (Revised 11/2012). Reviewed by Dave Chambers. Center for Science in Public Participation (CSP2)
- Gorini F, Muratori F, and Morales MA. 2014. The role of heavy metal pollution in neurobehavioral disorders: A focus on autism. *Rev J Autism Dev Disord* 1:354–72.
- Grandjean P, and Landrigan PJ. 2014. Neurobehavioural effects of developmental toxicity. *Lancet Neurol* 13:330–8.
- Hemphill S. 2017. State works to cut haze in northern Minn. wilderness areas. *MPR News*. Available: <https://www.mprnews.org/story/2012/03/27/epa-regional-haze-rule> [accessed 19 April 2018].
- Jacobs JA, Lehr JH, Testa SM. Wiley InterScience (Online service). 2013. *Acid Mine Drainage, Rock Drainage, and Acid Sulfate Soils: Causes, Assessment, Prediction, Prevention, and Remediation*. John Wiley & Sons, Inc., Hoboken, New Jersey.
- Kliegman RM, Stanton B, St. Geme J, *et al.* 2016. *Nelson Textbook of Pediatrics*, 20th ed. Elsevier, Inc, Philadelphia, PA.
- Kuipers JR, Maest AS, MacHardy KA, *et al.* 2006. Comparison of Predicted and Actual Water Quality at Hardrock Mines: The reliability of predictions in Environmental Impact Statements.
- McCann P. 2011. Mercury Levels in Blood from Newborns in the Lake Superior Basin: Available: <http://www.health.state.mn.us/divs/eh/fish/techinfo/newbornhglsp.html>.
- McClure LF, Niles JK, and Kaufman HW. 2016. Blood lead levels in young children: US, 2009–2015. *J Pediatr* 175:173–81.
- Minnesota water facts. 2010. Minn Dep Nat Resour. Available: https://files.dnr.state.mn.us/education_safety/education/minnaqua/leadersguide/appendix_1/7_5_water_facts.pdf [accessed 22 April 2018].

- Muller C, Sampson RJ, and Winter AS. 2018. Environmental inequality: The social causes and consequences of lead exposure. *Annu Rev Sociol* 44:263–282.
- Myers T. 2016. Acid mine drainage risks – A modeling approach to siting mine facilities in Northern Minnesota USA Tom Myers. *Journal of Hydrology* 533:277–290
- Myrbo A, Swain EB, Engstrom DR, *et al.* 2017. Sulfide generated by sulfate reduction is a primary controller of the occurrence of Wild Rice (*Zizania palustris*) in shallow aquatic ecosystems. *J Geophys Res Biogeosci* 122:2736–53.
- NorthMet Mining Project and Land Exchange. 2015. 3,576.
- One Health Initiative. 2018. Available: <http://www.onehealthinitiative.com/mission.php> [accessed 23 April].
- Onello E, Allert D, Bauer S, *et al.* 2016. Sulfide Mining and Human Health in Minnesota. *Minnesota Medicine*.
- Phillips S, and Alkire C. 2017. Sulfide-Ore Copper Mining and/or a Sustainable Boundary Water Economy: The Need to Consider Real Tradeoffs, p 42.
- Quigley RJ, and Taylor LC. 2004. Evaluating health impact assessment. *Public Health* 118:544–52.
- Ring S. 2014. Expert Statement. 16.
- Sasakamoose J, Bellegarde T, Sutherland W, *et al.* 2017. Miyo-pimātsiwin developing Indigenous Cultural Responsiveness Theory (ICRT): Improving Indigenous health and well-being. *Int Indigenous Policy J* 8:1.
- Shi L, Zanobetti A, Kloog I, *et al.* 2016. Low-concentration PM_{2.5} and mortality: Estimating acute and chronic effects in a population-based study. *Environ Health Perspect* 124:46–52.
- Social Determinants Of health: Know What Affects health. 2018. *Cent Dis Control Prev*. Available: <https://www.cdc.gov/socialdeterminants/> [accessed 23 April 2018].
- Stock JH, and Bradt JT. 2018. U.S. Forest Service (USFS) Environmental Assessment (EA) on Proposed 20-year Mineral Leasing Withdrawal in Superior National Forest.
- Ten chemicals of major public health concern. 2016. World Health Organ. Available: http://www.who.int/ipcs/assessment/public_health/chemicals_phc/en/ [accessed 19 April 2018].
- Timm DA, and Slavin JL. 2014. REVIEW: Wild Rice: Both an Ancient Grain and a Whole Grain. *Cereal Chem* 91:207–10.