THE SCIENCE: Proposed Sulfide-Ore Copper Mining Threatens Aquatic and Terrestrial Ecosystems of the Boundary Waters Region of the Boundary Waters Canoe Area Wilderness, the Superior National Forest, Voyageurs National Park, and Canada's Quetico Provincial Park, and public health and the regional economy of northeastern Minnesota.

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Predicted Ecological Impacts to the Boundary Waters Region of Sulfide-Ore Copper Mining

Tom Myers, Ph.D. **2013. In his report entitled "Technical Memorandum: Twin Metals Mining and the Boundary Waters Canoe Area Wilderness, Risk Assessment for Underground Metals Mining," Dr. Myers focused on essential facts demonstrating why sulfide-ore copper mining threatens irreparable harm to priceless northern forest ecosystems** (Parentheticals explain why facts identified by Dr. Myers are significant):

- Waters that would receive acid mine drainage (AMD) are currently of extremely high quality (therefore, pollution caused by mining would degrade an increasingly rare resource).
- The waters that would receive AMD contain few base compounds (therefore, natural buffering of AMD will be extremely low).
- The many streams, wetlands, lakes and aquifers downstream of the mine sites are massively interconnected (therefore, damage from AMD will be widespread and uncontrollable).
- Mine sites lie in close proximity to these water resources (therefore, preventing AMD from entering the waters would be impossible).
- The high probability of AMD coming from the mine sites, waste rock piles, and tailings pond failures (no practical possibility exists of preventing air, rainwater and snowmelt from reaching sulfide-bearing rock).
- The difficulty of predicting when and where AMD may occur because of the nature of cracks and faults in the bedrock (therefore, no practical possibility exists of effectively blocking AMD movement through the ground).
- The potential that AMD could impact waters far downstream from the mine sites (therefore, major waterways of the Boundary Waters Canoe Area Wilderness, Quetico Provincial Park and Voyageurs National Park would be threatened).
- The high cost and low probability of remediating AMD when it occurs.
- River discharge and aquifer recharge are highly seasonal, with the bulk of it occurring between mid-April and mid-June (therefore, drawdowns of surface water and groundwater by mining activity outside that period of higher flows will deplete water available in the affected ecosystems at times when the flows are already at annual or decadal low points).

Dr. Myers **later developed a model for the Rainy Headwaters that shows the flow of ground and surface water and the transport of contaminants, 2014. "Technical Memorandum: Twin Metals Mining and the Boundary Waters Canoe Area Wilderness, Risk Assessment for Underground Metals Mining."** The Rainy Headwaters includes the South Kawishiwi, Birch Lake, and Stony River watersheds. The purpose of the model is to estimate pathways and rates for contaminants to reach the Boundary Waters Canoe Area Wilderness if sulfide-ore copper mining occurs within these watersheds. The model can be used to estimate the risk of mine spills and leaks affecting the Boundary Waters Canoe Area Wilderness and the lakes and rivers between the proposed mines and the Wilderness. Dr. Myers modeled three

scenarios for underground mines and a proposed concentration facility in the South Kawishiwi and Birch Lake watersheds based on the Twin Metals Minnesota Pre-Feasibility Study.

- First scenario: a release of a conservative pollutant (sulfate) from five locations in underground mines using a realistic concentration of sulfate for closed and flooded underground mines in the Duluth Complex and a low discharge rate.
- Second scenario: a one-year release to groundwater from mine waste stored on the surface in the watershed, representing a range of releases that can occur.
- Third scenario: a mid-level spill at the Maturi mine site and at the proposed concentration facility site.
- Scenarios one and two (releases) show that substantial contaminant loads from leaks typical of sulfide-ore mining could impact waters that drain into the Boundary Waters Canoe Area Wilderness.
    - Once started, leaks would continue for decades (even a short-term spill would take years or decades to travel through groundwater) and would thus likely coincide with low flow periods and could create devastating impacts.
    - Contaminants entering the rivers and lakes during low flow conditions have a high potential to impact water in the Boundary Waters Canoe Area Wilderness.
    - Historically, it has been almost impossible to stop leaks at similar mines.
    - Leaks would have a significant impact on streams, rivers, wetlands, rivers and other waters adjacent to the sulfide-ore copper mine sites and in the Superior National Forest.
    - Pollution from sulfide-ore copper mines in these areas would extend into the Boundary Waters Canoe Area Wilderness.
- Scenario three (a spill at the proposed concentration plant) could devastate adjoining lakes, rivers and streams in the Superior National Forest.
- A spill could have a devastating impact on the Boundary Waters Canoe Area Wilderness, depending on level of toxicity, load and location.
- "If the sulfide mines are developed in the Rainy Headwaters, 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."

Dr. Myers **extended his analysis to consider the risks posed to Voyageurs National Park from the development of metallic mineral leases in the watersheds draining to and through it, including the Rainy Headwaters, Vermillion Lake, and Rainy River-Rainy Lake Watersheds. In his 2015 "Technical Memorandum: Potential Metals Mining and the Voyageurs National Park Risk Assessment for Upstream Metals Mining"** prepared for the Voyageurs National Park Association and National Parks Conservation Association," Dr. Myers reported:

- Streams draining toward Voyageurs National Park have high water quality and would be affected by small amounts of contamination for a long time.
- The low buffering capacity of the rivers in the Rainy Headwaters watershed could allow contamination from mining waste to be transported a long distance downstream, including to Voyageurs National Park.
- Contaminant seepage into groundwater could last for decades, and there would be little chance of preventing the pollution from reaching Voyageurs National Park.
- Mercury contamination is already present in Voyageurs National Park, and AMD seepage over a long time period would likely exacerbate the existing mercury problem.
- A spill in the Vermilion watershed could pose critical threats to Voyageurs National Park, especially if the waste flowed through Vermilion Lake instead of mixing.
- Discharge or leaking of high salinity water resulting from mine dewatering could ruin nearby streams and increase total dissolved solids from the Kawishiwi River to Voyageurs National Park.
- Development of tailings impoundments presents a large risk to Voyageurs National Park, especially considering their proximity to the river system, the need for a tailings impoundment to not fail forever, the connectivity of the surface waters in the watershed and increases in extreme weather events due to climate change.

***Dr. Myers* condensed and submitted for publication his numerical hydrological model in the peer-reviewed Journal of Hydrology. In the paper, published in February, 2016 and titled, "Acid mine drainage risks – A modeling approach to siting mine facilities in Northern Minnesota USA,"** *(J.Hydrology* 533: 277-290), Dr. Myers demonstrated that:

- Groundwater with substantial contaminant concentrations would discharge to streams whether sourced from deep underground or on the ground surface.
- Even relatively short-term leaks on the surface could cause substantial loads of pollutants to reach the rivers and valuable downstream resources. Underground leaks have lower discharge concentrations but continue for long time periods, such that contamination may not be obvious until after a mine closes and impacts can continue for hundreds of years.
- Longer-term leaks could cause peak concentrations reaching the rivers to be much higher than simulated.
- Releases trending southwest to northeast in the Birch Lake area would discharge to surface water relatively quickly.
- Releases in the headwaters of the Stony River would discharge to nearby surface water.
- Under the course of normal operations, proposed mines near the Boundary Waters Canoe Area Wilderness could cause significant damage to rivers and the Boundary Waters due to leaks to surface waters or substantial groundwater contamination.

***Dr. Myers* developed and applied a numerical groundwater model to assess the relationship between the proposed Twin Metals Minnesota tailings storage facility and the management and closure of the Peter Mitchell Pit,** which is a series of taconite mine pits that have substantial effect on the local groundwater system. The Laurentian Divide, the boundary separating the Boundary Waters Canoe Area Wilderness and Lake Superior watersheds, naturally and originally ran across what is now the location of the Peter Mitchell Pit. Dr. Myers summarized the findings of the model in his 2016 technical memo titled "Twin Metals Mine and the Peter Mitchell Pit, Simulation of the Development of the Peter Mitchell Pit and Its Effects on the Proposed Twin Metals Tailings Impoundment:"

- Removal of bedrock pillars separating the Lake Superior and Boundary Waters Canoe Area Wilderness watersheds during mining prior to closure of the Peter Mitchell Pit, will essentially move the watershed boundary for a period of time.
- Heavily contaminated seepage from the proposed Twin Metals tailings storage facility would flow from the tailings facility through the bedrock and into the Peter Mitchell Pit for a period of 25-50 years, and thus into the Boundary Waters Canoe Area Wilderness watershed.

***Dr. Myers' report of February 2018* "Technical Memorandum: Twin Metals Mining and the Boundary Waters Canoe Area Wilderness, Identifying Flow Pathways" describes the numerous available pathways through bedrock and surficial aquifers for mining contaminants to reach surface waters in the watershed of the Boundary Waters Canoe Area Wilderness and the methods to estimate or map pathways.** His report concludes with a qualitative risk assessment of transport of pollution to the Boundary Waters Canoe Area Wilderness and documents the evidence that groundwater pathways exist to transport pollution into the Wilderness. His report refutes claims that geophysical analysis and video of boreholes can be determinative for location and connectivity of fractures that could transport contaminants into surface waters.

- "The conclusion is that mining in the Rainy headwaters presents a substantial risk to water quality in the BWCAW. The risk is from spills on the surface, leaks from the surface storage of waste, even temporary stockpiles, and from seepage through buried waste. Geophysical analyses of boreholes cannot provide evidence of a lack of connectivity through bedrock to the surface. It is not possible for video of boreholes to show the length of fractures to show their lack of connectivity."

Lawrence A. Baker, Ph.D. **2013. In his report entitled "Potential Ecological Impacts of the Twin Metals Mine,"** Dr. Baker stated the following conclusions, among others:

- "The potential impacts of the mine are high because this is a very large mine located in an ecologically sensitive area."
- Fish in these waters are sensitive to acidification; even small changes in pH caused by acid mine drainage (AMD) would result in losses of species. If pH were to decline below 5.0 most species would be lost.
- Leaching of heavy metals associated with AMD impairs fish and other aquatic life.
- Because wild rice is harmed or destroyed by sulfate levels greater than 10 mg/L, and because background sulfate levels in these waters are around 6 mg/L, elevated sulfate levels associated with sulfide-ore copper mining would likely impair wild rice production. It may also harm other rooted aquatic plants.
- Sulfates are a factor in the creation of methyl mercury, which is the form of mercury taken up in the food chain. The increased methylation would increase the concentrations of mercury in fish and thus expose human and other consumers of fish to the risks associated with elevated levels of mercury in their bodies.
- AMD input and elevated sulfate levels would affect the natural cycling of phosphorus between sediments and waters. The release of phosphorus to waters would cause increased algal growth, loss of water clarity and eutrophication.
- AMD and associated contamination may affect a large number of shallow, easily contaminated domestic drinking wells in the area.
- Tailings dam failures, because of an extreme weather event, human error or other reason, pose a serious risk to downstream ecosystems; the downstream distribution of acidic water and sediments contaminated with heavy metals would pollute many kilometers of waters. Damage from metal-laden sediments would persist for years.

Dr. Baker **extended his** analysis to model the chemical impacts of a possible spill at the Twin Metals mine site, the impacts of water usage by the mine, and the confounding influence of climate change on mine impacts. He reported:

- A mixing model based on observations and studies of realistic AMD generation potential would result in elevated sulfate levels "well above" Minnesota's 10 mg/liter wild rice standard and likely accelerate mercury methylation in sediments.
- Water withdrawal for copper production is projected by company documents to be 0.8 million gallons per day; water usage in Ely is estimated to be about 0.94 million gallons per day for comparison. Water usage for sulfide-ore copper mining could reduce the decadal low flow of the South Kawishiwi River by 7-13%.
- Water usage, energy usage and tailings productions per unit copper produced increase over the life of a mine.
- Climate change will make it even more difficult to predict impacts, especially those triggered by more extreme precipitation events that threaten mine infrastructure like tailings dams, process ponds and tailings pipelines.

Daniel Engstrom, Ph.D. **2017. Dr. Engstrom is one of the lead scientists studying the effects of sulfate on mercury cycling, wild rice, and sulfur biogeochemistry in Minnesota. In his comment letter to the Forest Service, Dr. Engstrom describes the risk of sulfide-ore copper mining to the Boundary Waters Canoe Area Wilderness** and concludes:

> "The BWCAW is classified as 'outstanding resource value water' under the Minnesota statutes (MAR 7050.0180), whereby: 'The agency [MPCA] recognizes that the maintenance of existing high quality in some waters of outstanding resource value to the state is essential to their function as exceptional recreational, cultural, aesthetic, or scientific resources. To preserve the value of these special waters, the agency will prohibit or stringently control new or expanded discharges from either point or nonpoint sources to outstanding resource value waters.' (MAR 7050.0180 Subpart 1). Given the abundant evidence…that sulfate releases from mining operations through the Kawishiwi watershed and into the BWCAW pose substantial environmental risk to these outstanding resource value waters, it is scientifically prudent that mining leases held by Twin Metals and other mining interests be withdrawn by the Secretary of the Interior for a 20-year term as requested by the Forest Service."

The Minnesota Pollution Control Agency Wild Rice Sulfate Study peer-reviewed and published reports were completed in late 2017. *They include the following four published papers:*

"increase in Nutrients, Mercury, and Methylmercury as a Consequence of Elevated Sulfate Reduction to Sulfide in Experimental Wetland Mesocosms" ***by A. Myrbo, et al*** *(Journal of Geophysical Research: Biogeosciences, 2017****)*** makes these key points:

- Sulfate addition increased organic matter mineralization in wetland sediment, releasing C, N, P, and Hg to the water column.
- Sulfate reduction caused not only higher methylmercury concentrations but higher total mercury concentrations in the surface water.
- Increased sulfate loading to freshwaters can cause deleterious effects separate from direct sulfide toxicity to organisms.

"Sulfide Generated by Sulfate Reduction is a Primary Controller of the Occurrence of Wild Rice (Zizania palustris) in Shallow Aquatic Ecosystems" ***by A. Myrbo, et al*** *(Journal of Geophysical Research: Biogeosciences, 2017)* makes these key points:

- Sulfate loading to freshwater ecosystems may alter aquatic plant communities when sulfate is reduced to sulfide in the anoxic rooting zone.
- The occurrence of self-sustaining wild rice populations is mainly controlled by pore water sulfide concentrations.
- Even if pore water sulfide is low, wild rice is less likely to be found if the surface water is turbid or warm.

"Effects of sulfate and sulfide on the life cycle of Zizania palustris in hydroponic and mesocosm experiments" ***by John Pastor, et al*** *(Ecological Applications 2017)* made these findings:

- In hydroponic solutions, sulfate had no effect on seed germination or juvenile seedling growth and development, but sulfide greatly reduced juvenile seedling growth and development at concentrations greater than 320 ug/L.
- In outdoor mesocosms, sulfate additions to overlying water increased sulfide production in sediments. Wild rice seedling emergence, seedling survival, biomass growth, viable seed production, and seed mass all declined with sulfate additions and hence sulfide concentrations in sediment. These declines grew steeper during the course of the 5-year mesocosm experiment and wild rice populations became extinct with concentrations of 250 mg SO4/L or greater in the overlying water.
- Iron sulfate precipitated on the roots of wild rice plants and may impede nutrient uptake and be partly responsible for reduced seed production and viability.

"The Evolution of Sulfide in Shallow Aquatic Ecosystem Sediments: An Analysis of the Roles of Sulfate, Organic Carbon, and Iron and Feedback Constraints Using Structural Equation Modeling" ***by Curtis C. Pollman, et al*** *(Journal of Geophysical Research: Biogeosciences, 2017)* makes these key points:

- Factors controlling pore water sulfide, which can be toxic to wild rice, where identified with structural equation modeling.
- Structural equation modeling was used to quantify the relative effects of sulfate, iron, and TOC on pore water sulfide concentrations.
- The concentration of pore water sulfide is controlled nearly equally by sulfate in surface water and sediment organic carbon and iron.

Paul Venturelli, Ph.D., and Bruce Vondracek, Ph.D. **2017. Drs. Venturelli and Vondracek describe in their report "The Fish and Fisheries of the Boundary Waters Canoe Area Wilderness and Voyageurs National Park, and Their**

Vulnerability to Copper Sulfide Mining" the fish and fisheries of the Boundary Waters Canoe Area Wilderness and Voyageurs National Park, and their vulnerability to copper sulfide mining. Important points include:

- The Boundary Waters Canoe Area Wilderness and Voyageurs National Park support important, healthy recreational and subsistence fisheries with high species and genetic strain richness, which are a direct result of past efforts to maintain the pristine nature and ecological integrity of the region.
- A comparison of fish catches inside and outside of the Boundary Waters Canoe Area Wilderness and Voyageurs National Park suggests that anglers target the Boundary Waters Canoe Area Wilderness and Voyageurs National Park when fishing for lake trout (and other prized cold-water species) and smallmouth bass. State survey data suggest that some game fish species are larger in the Boundary Waters Canoe Area Wilderness and Voyageurs National Park, probably due to relatively large lakes and pristine habitat, and low fishing pressure.
- The scientific literature indicates that acid mine drainage causes long-term declines in fish abundance, species number, and genetic diversity, and may facilitate the establishment of invasive species;
- Acid mine drainage lowers pH and exposes fish and other aquatic organisms to toxic metals (e.g., copper, cadmium, lead, mercury, nickel, and zinc), which accumulate in all major organs, impair system function, cause deformities, behavioral changes, reproductive failure, and mortality, and may render fish unfit for human consumption.
- Evidence from previous hard rock mines demonstrates overwhelmingly that a copper-sulfide mine in the Rainy River watershed will impact fish, and that such damage is likely to extend far from the mine site and persist for centuries causing damage to a relatively pristine region of the state, and the diversity of popular and rare fishes that it supports.

Lee Frelich, Ph.D. **2014. Dr. Frelich, in his report "Forest and Terrestrial Ecosystem Impacts of Mining" has determined that significant negative impacts of sulfide-ore mining would likely occur on terrestrial ecosystems of the Boundary Waters Canoe Area Wilderness and adjacent areas of the Superior National Forest.** Those impacts include, among others:

- Forest fragmentation within the mining area, the effects of which would extend into the Boundary Waters Canoe Area Wilderness.
    - Forest fragmentation results in changes to both plant and wildlife communities.
    - Of particular concern are species such as fisher, pine marten and interior forest songbirds that need large tracts of unfragmented forest.
- Disruption of the intricate web of water that flows through the soil, forest roots and other organisms lying on top of bedrock throughout the Quetico-Superior ecosystem. Construction of roads, waste storage and water drawdown would repeatedly disrupt water flow and cause significant additive and cumulative impacts:
    - Interference with the interaction between forests, streams and groundwater.
    - Interference with the flow and chemistry of the water in the ecosystem, resulting in changes in decomposition and nutrient cycling, changes in balance of vegetation types and tree mortality.
    - Because of the interconnectedness of the systems, activities outside the Boundary Waters Canoe Area Wilderness would have impacts within the Wilderness.
- Dispersal of invasive plant species, which would extend beyond the actual surface disturbance from mines and transportation infrastructure.
- Dispersal of nonnative earthworms, which are present but not yet well-established in the area.
    - The movement of soils associated with mining would very likely spread nonnative earthworms to areas not currently infested.
    - Fragmentation would speed nonnative earthworms' movement across the landscape.
    - Earthworms can trigger a variety of impacts with a wide range of ecological repercussions.
- Loss of native biodiversity.

    - Soil dwelling species that have not yet been discovered, including insects, worms, bacteria and fungi, probably exist in the mining area and could be lost both within the mining footprint and beyond.
- Effects of a vast increase in traffic, including heavy truck traffic, close to the Boundary Waters Canoe Area Wilderness that mining would entail. For example, road salt is likely to cause root damage and tree death for species such as white pine, basswood, red oak, bur oak and red maple. Other impacts of roads on ecosystems and wildlife are well known.
- Changes in wildlife migration and habitat use patterns.
- Effects of windblown dust and other forms of air pollution.
- Additive and synergistic effects of mining with the effects of climate change.
    - Mining would add a significant stressor to a system that will already be stressed, perhaps beyond the point of resiliency.
- Loss to science: the Boundary Waters Canoe Area Wilderness provides a baseline for a landscape otherwise affected by logging, mining, roads, housing and other human activities.
    - "This role of wilderness and other natural areas as a scientific baseline has become critical in the last few decades, to assess the overall impacts of human activity at local, regional and global scales. Without these baselines, we are essentially 'flying blind' in our ability to manage ecosystems to provide the many types of services needed by humanity."

Lee Frelich, Ph.D. **2019. "Terrestrial ecosystem impacts of sulfide mining: scope of issues for the Boundary Waters Canoe Area Wilderness, Minnesota, USA." (***Forests* (2019) 10, 747). **Boreal forests are one of the world's leading providers of ecosystem services including carbon storage and clean water, have a large impact on climate at local, regional, and global scales, harbor globally significant wildlife populations and large tracts of unlogged primeval forest important to maintaining biodiversity. Mining is one of the major environmental threats to boreal forests worldwide.**

- The Boundary Waters Canoe Area Wilderness' significant wildlife populations and large tracts of native vegetation and unlogged primeval forest show, and allow scientists to study, how natural disturbances and landform variability interact to maintain biodiversity.
- The ecological footprint of mining includes CO_2 emissions, water use, and impacts to biodiversity. In the event of proposed mining on the edge of the Boundary Waters Canoe Area Wilderness in Northeastern Minnesota, USA, these dynamics would play out with multiple impacts over a set of distances and spatial patterns corresponding to different direct and secondary footprints on surrounding terrestrial landscapes.
- The potential terrestrial impacts from mining near the Boundary Waters on the Quetico-Superior ecosystem are numerous and, "it is reasonable to state that most (25 of 39…) impacts will affect the [Boundary Waters Canoe Area Wilderness] to some degree."
- "The living portion of the BWCAW ecosystem is like a thin membrane with many fine-scale interconnections among paths of water flow, lying on top of undulating bedrock. A large primary footprint of mining activity at the top of the watershed can cause many effects related to water flow and chemistry (including aerial deposition), that will affect everything lower in the watershed. Given the high level of linkages between aquatic and terrestrial components of the ecosystem in the BWCAW, these effects will also extend into terrestrial vegetation. Changes in forest type, soils, and fragmentation, within the terrestrial primary footprint will also impact invasive species, and via spatial propagation into the secondary footprint and subsequent ecological cascades; these will affect vegetation, wildlife, and rare species of plants and animals within the BWCAW…."

David. C. Wilson, Randall S. Morin, Lee E. Frelich, and Alan R. Ek. **2019. "Monitoring disturbance intervals in forests: a case study of increasing forest disturbance in Minnesota."** *(Annals of Forest Science* (2019) 76:78). Disturbance plays an important role in the dynamics of natural forests. Biotic and abiotic changes can disrupt stand structure, resource availability, and/or the physical environment. Such disturbances can range spatially from small-scale to large-scale, stand-to-landscape replacing events. The rotation interval for disturbance (not necessarily stand-replacing) varies

widely with many factors. Rates of disturbance may vary with time, depending on long-term climate trends, anthropogenic land use patterns, wildlife population cycles, and other factors. These disturbances, in total, drive successional change in the forest. Rates of disturbance are relevant to timber production and harvest, carbon sequestration, habitat management, biodiversity, and ecosystem services consideration.

Increasing disturbances associated with climate change, invasive plant and animal species, invasive tree pests, and diseases, have been reported in Minnesota's northern forest. This paper documents an analysis confirming that rotation intervals for seven disturbance types have shown a marked and statistically highly significant decrease in Minnesota's northern forest between 2001 and 2014. Many disturbance types are directly or indirectly related to climate change.

Roger A Powell, Ph.D. **2017. In his report, "Mammals and Mining for Minerals in Sulfur-Bearing Rock Formations in Northeastern Minnesota", Dr. Powell describes the life histories and vulnerabilities of the mammals of the Boundary Waters Region to effects of sulfide-ore copper mining.** Effects of sulfide-ore copper mining on mammals of the Boundary Waters Region would result via numerous pathways, such as:

- pollution of water (all mammals drink).
- pollution, diminishment, or eradication of aquatic vegetation on which many mammals rely as habitat, for forage, or for nutrients like sodium.
- contamination and bioaccumulation of toxic metals such as methyl-mercury in fish and in mammals that consume fish.
- the direct, indirect, and cumulative effects caused by fragmentation of terrestrial habitat required for foraging, mating, rearing, denning, and dispersal.
- destruction of important habitats, such as mature forested habitats and mature forest-wetland complexes.

John W. Fitzpatrick, Ph.D., Executive Director, Cornell Lab of Ornithology**. 2017. In his report, "Birds of Minnesota's Boundary Waters Canoe Area and Adjacent Upstream Regions, with Comments on Conservation Implications of New Copper Mining Under Consideration," Dr. Fitzpatrick summarizes the outstanding bird resources of the Boundary Waters Canoe Area Wilderness and adjacent mosaic of habitats located in the Superior National Forest, immediately outside of the Boundary Waters Canoe Area Wilderness, with specific attention to those areas subject to potential copper mining.** The Boundary Waters Region is very well known and popularly visited by birders worldwide, who are drawn to the area because the extremely high water quality and mosaic of habitat types in the Laurentian Mixed Forest hosts extraordinary bird species diversity. Key points raised include:

- 225 bird species regularly occur in the Superior National Forest.
- 163 of those species are documented as breeding within the Boundary Waters Canoe Area Wilderness and surrounding areas, *representing 74% of the list of bird species that regularly breed in Minnesota*.
- 60 additional bird species regularly depend on the Boundary Waters Canoe Area Wilderness and surrounding areas as stop-over sites on spring and fall migration.
- 13 of the 86 bird species identified as of significant "continental concern" by North America's two premier bird conservation consortia (Partners In Flight or PIF, and the North American Bird Conservation Initiative (NABCI)), are hosted in the Boundary Waters Region. "Every possible effort to conserve or restore their highest-quality habitats is essential for conservation of the species," and "therefore, maintaining the pristine condition of all BWCAW regional habitats" is vital to their long-term conservation.
- The coniferous forests and forest wetlands of the Boundary Waters Region support from 25% to 100% of the habitat of Minnesota's boreal-zone species, most of which are designated by PIF as "species of stewardship priority for Minnesota."
- The Boundary Waters Region supports the highest diversity of breeding wood warbler species anywhere in the world – 24 species of wood warblers, which represent 2/3 of all species breeding east of the Great Plains.

- 99 bird species depend on the Boundary Waters Region's superb aquatic habitats, 31 species for breeding, and 68 for pass-through feeding and resting during migrations.
- The common loon – the iconic state bird and bio-indicator of freshwater ecosystem health – is a top trophic-level consumer and thus highly susceptible to bioaccumulation of methylmercury and other potent heavy metal toxins. Numerous studies have shown these cause negative effects on loon physiology, feather symmetry, behavior, chick survival, and reproductive success.
- The common loon population on the Superior National Forest experienced an annual decline of 4.2% from 1995 to 2016.
- Even marginal increases in mercury methylation from mining operations could substantially impair common loon populations, and the larger community of fish-eating bird species that rely on the pristine resources of the Boundary Waters Region.

Dave Chambers, Ph.D. **2014. Dr. Chambers reviewed sulfide-ore copper mining in the Duluth Complex and currently available copper mining technologies in his November 2014 report, "The Potential for Acid Mine Drainage and Other Water Quality Problems at Modern Copper Mines Using State-of-the-Art Prevention, Treatment, and Mitigation Methods."** Dr. Chambers found:

- Most of the waste rock and pit wall rock so far studied in the Duluth Complex would contain some sulfur, mainly as the mineral pyrrhotite, a primary cause of AMD. There are essentially no acid-neutralizing carbonate minerals in the waste rock.
- Copper is particularly toxic to aquatic organisms, but current National Ambient Water Quality Criteria for Protection of Aquatic Life for copper are not totally protective of all aquatic species.
- Uncertainties based in the inherent complexity of natural materials and their environments prevent predictive ability, which prevents the conclusion that a mine will have only insignificant impacts.
- Difficulties of adjusting water treatment and seepage collection technologies to meet real-world chemical composition, geomorphology and water cycle variation are much greater than suggested by assumptions within the environmental assessment process.
- No significantly new water treatment technologies have been developed in recent decades. The most complete systems, including reverse osmosis, are highly expensive and require their own follow-up treatment systems.
- No tailings storage facility seepage collection system is perfect ("all liners leak") and disposing of tailings or waste rock in an old facility would likely use an unlined system.
- The U.S. Environmental Protection Administration has observed that mines continue to operate even if they know their treatment does not meet established water quality standards.
- Records of analogous mines indicate a high likelihood that any mine would release water exceeding its environmental permit within its lifetime.
- "It is not feasible, given today's or tomorrow's technology, to reduce the risk of impacting waters downstream from a copper/nickel mine in a sulfide ore body to zero."

Dr. Chambers **addressed the potential for acid mine drainage in his February 2018 report "Potential for Acid Mine Drainage in the Duluth Complex Magmatic PGE Deposits."** Key points from his report are:

- The Duluth Complex contains disseminated metal sulfides that are proven to lead to acid generation.
- Both open pit and underground mining are possibilities for mining the disseminated copper-nickel deposits in the Duluth Complex (for example, the Spruce Road deposit will likely be an open pit mine; the Maturi and Birch Lake deposits will likely be underground mines; the Maturi SW deposit will likely begin underground and may be mined to the surface because of the location of metal minerals within 15 feet of the surface).
- Metal mining produces a large amount of waste because of the relatively small amounts of desirable metal contained in most deposits.

- Both tailings and waste rock can be sources of dissolved metal and other ionic contaminants, which affect both surface and ground waters.
- Key environmental characteristics of waste rock and tailings at the NorthMet deposit have been thoroughly studied for years; it is located in the Duluth Complex southwest of the watershed of the Boundary Waters Canoe Area Wilderness and approximately 6 miles from the Dunka Mine.
    - Most of the waste rock and pit wall rock will contain some sulfide sulfur which can produce acid leachate and soluble metals when it oxidizes.
    - There are no acid-neutralizing carbonate minerals in the waste rock.
    - Sulfide-bearing rocks may oxidize for several years before producing acidic leachate.
    - The rate of sulfide mineral oxidation in waste rock would be approximately proportional to the total sulfur content of the material and the rate could increase several-fold if the pore water were to be become acidic.
    - If pore-water pH were to shift from neutral to acidic, then the rate of sulfide mineral oxidation and associated release of metal cations (e.g., nickel and copper) would increase dramatically
    - The mechanism most responsible for the release of contaminants from waste rock and tailings is oxidation of sulfide minerals, primarily pyrrhotite ($Fe_{(1-x)}S$). The sulfide-oxidation reaction produces sulfuric acid, and releases soluble metals (e.g., cobalt, copper, iron, and nickel) that is bound in sulfide minerals. At the NorthMet deposit, secondary effects include leaching of some metals (primarily nickel and chromium) from silicate minerals, particularly where acidic pore waters increase silicate solubility.
    - Mine-related blasting and excavation dramatically increases the surface area and porosity of the rock, which allows rapid introduction of atmospheric oxygen and flushing of solutes by water. Within the pit walls and underground workings, the blasting effects increase the surface area available for oxidation for approximately 50 feet surrounding the blast holes. Water that comes into contact with pit walls and underground workings, especially after mine closure, can be expected to be contaminated.
    - Waste storage is an issue in the Duluth Complex because the terrain is relatively flat and it is difficult to find large areas where bedrock is shallow or exposed. Groundwater flow is more complicated and less restricted in both depth and area in comparison to a site located in the mountains. As a result, containing and/or collecting groundwater is more difficult and expensive.
        - Dr. Myers has shown that a tailings basin located outside the watershed of the Boundary Waters Canoe Area Wilderness in the location identified by Twin Metals Minnesota will pollute waters in the Boundary Waters watershed by way of the Peter Mitchell mine pit.
- The Dunka Mine, a taconite mine located a mile from the Twin Metals Birch Lake deposit and within 10 miles of the Maturi SW, Maturi, and Spruce Road deposits, had an over-burden of sulfide-bearing ore that was stockpiled in five waste piles approximately 40 years ago.
    - All of this sulfide-ore waste is producing acidic drainage.
    - Most of the seeps from waste rock drain into Unnamed Creek, which flows into Bob Bay of Birch Lake.
    - The Dunka pit is overflowing and drains into the Dunka River.
    - The levels of sulfate discharged from waste rock is two orders of magnitude greater than the level of background sulfate in most of the lakes and streams in the watershed.
    - The passive water treatment systems are not meeting water quality standards for nickel at three locations and the water quality standard for zinc is probably being exceeded.
- Key conclusions of Dr. Chambers:
    - The mineralization of the Maturi, Maturi SW, Birch Lake, and Spruce Road deposits, which contain sulfides at higher concentrations than the NorthMet or Dunka mine waste rock, could be expected to

produce the same contaminants as at Dunka, but at higher rates and concentrations due to the higher amounts of sulfide mineralization and lower pH this waste will likely yield.
    - Like Dunka, at all of the sulfide mine developments in the Duluth Complex it is extremely likely there will be seepage from waste rock, pit walls, and tailings to ground and/or surface waters that will require treatment for elevated levels of metals, and potentially sulfate.
    - Sulfate levels of the discharges from conventional and passive water treatment systems will not be reduced, and will be two or more order of magnitudes higher than the Minnesota water quality standard for sulfate of 10 mg/L.

Dr. Chambers **critiqued "Twin Metals Minnesota Project – Acid Mine Drainage White Paper" by Golder Associates and "Lack of Hydrological Basis for BLM and USFS Decision to Reject Renewal of Twin Metals Minnesota's Mineral Leases and Potentially Withdraw Federal Minerals in the Rainy River Watershed" by Foth Infrastructure & Environment. 2018.**

- Golder addresses only one deposit – Maturi – and fails to address all other deposits that would be mined as underground and open pit mines.
    - As to Maturi, Golder does not address fully developed geochemical, hydrological, or mining data.
    - Backfilling of waste rock into Maturi will be limited due to a shortage of space in an underground mine.
    - At a similar underground mine, predictions that space would be adequate to store all acid generating waste rock proved wrong, and much of the waste rock is now on the surface and clearly acid generating.
    - Open pits in the Withdrawal Study Area will result in significant problems because of the potential to generate acid and metal contaminants.
    - In most metal deposits, iron sulfides are the most common minerals.
        - Iron sulfides have no economic value and end up in tailings and waste rock.
        - Iron sulfides are the primary source of acid mine drainage.
        - Acid mine drainage from iron sulfide waste rock can occur at rates hundreds to thousands of times that of natural weathering.
    - The possibility of unanticipated, unpredicted, results from mining must be considered when reviewing whether mining should be allowed in an area.
- Foth's basic premise is fundamentally flawed.
    - Foth fails to provide a defensible regional hydrological model that shows contamination, even if it occurred, could not negatively affect the Boundary Waters.
    - Foth criticized consideration of pre-1990 mine failures yet failed to acknowledge numerous post-1990 mines that are causing significant environmental impacts.

Stu Levit, M.S., J.D., **provides contextual information about the Duluth Complex and an overview of the inherent processes and facilities necessary at any sulfide-ore copper mining project in the Duluth Complex, and the types of impacts that these mining related processes and facilities have on the landscape and the ecosystem (February 2018).** He concludes that the majority of mine features are predictable and many of their impacts to human health and the environment are similarly predictable.

- Almost all mines degrade onsite and offsite resources – impacting lands, natural resources, ecosystems, and ecosystem-based functions.
    - The Levit report is consistent with statements by Minnesota copper mining industry representatives: "Mining by its nature and scale causes significant changes in the landscape and ecosystem" (Minnesota Mining and Global Minerals Engineering).
- Sulfide-ore copper mining next to the Boundary Waters Canoe Area Wilderness and in the headwaters would almost certainly impact water, air, quiet, the night sky, people, and wildlife resources.

- "The BWCAW is a unique water-based wilderness area characterized by very high water quality and an extensive interconnected system of surface and ground waters. Predictable impacts, most notably to water, from mining in the Duluth Complex could significantly alter the BWCAW's natural resource and wilderness values."

In his second report "Follow-up Report: Acid Mine Drainage and other Water Quality Problems at Modern Copper Mines Using State-of-the-Art Prevention, Treatment, and Mitigation Methods" (February 2018), ***Stu Levit*** assessed current state-of-the-art mining practices and technologies and assumed current best practices to determine if it was possible to eliminate risks to water quality and other natural resource values in the immediate and downstream areas of sulfide-ore mines should they be developed next to the Boundary Waters Canoe Area Wilderness and along lakes and rivers that flow directly into the Wilderness.

- Levit concluded that it is not possible to eliminate risks to waters that flow into the Boundary Waters Canoe Area Wilderness.
- Mines create many sources of contamination that have been extensively documented and are summarized in this report.
    - Proximity to surface water and ground water is associated with higher rates of acid, heavy metals, and other contamination of those waters.
    - Financial, social, or other factors – including simple impossibility or impracticability, render mine reclamation or rehabilitation unlikely.
        - Reclamation failures are often significant sources of contamination.
        - Failure of any major component – such as a tailings impoundment or acid mine drainage formation in a waste rock pile contaminating surface and/or ground waters – is a failure of reclamation.
        - Contamination also occurs from multiple minor deficiencies (or failures) that cumulatively are capable of considerable harm.
    - Airborne contaminants from mine facilities could likely reach waters in, or that flow into, the Boundary Waters either by direct deposition to water or by being washed into surface waters or ground water.
    - Impacts from noise and light can uniquely threaten wilderness resources and values.
    - The effects of mine dewatering and ground water drawdown can be substantial, affecting hydraulic conductance/ connectivity within and between surface and shallow or deep ground water, among other impacts.
    - Water contaminant leaks have historically been shown to be almost impossible to prevent or fully clean up. Contaminants can also enter sediment and become part of a cycle of moving between sediment and the water column and move downstream during storm transport of bedload sediment.
        - Flows into and between groundwater and surface waters would make remediation particularly complex and improbable.
    - Mines in wet regions, such as the Boundary Waters Canoe Area Wilderness, are highly likely to have a spill, leak, seep, failure, unanticipated impact, human error, and/or other unintended event that results in an irrecoverable release of contaminants to ground water and/or surface waters.
        - A review of the track record of water quality impacts from sulfide-ore copper mines found severe impacts to water, contamination of farmland, contamination of water body sediments, harm to and loss of fish and wildlife and habitat, and risks to public health.
        - In some cases, acid mine drainage will generate water pollution in perpetuity.
        - Most modern copper mines are located in arid environments that have less extensive surface water resources and volumes than in the Boundary Waters Region.
        - The wet environmental of the Boundary Waters Region increases the likelihood that mines in the area will have contamination and containment problems.

        - These problems, notably water collection and treatment failures, will probably get worse after mining ends and groundwater pumps are no longer keeping the mine area/ workings dewatered.
- Levit reviewed the track record of copper mines in North America for containing contaminants and for preventing large-scale releases.
    - Project-specific reviews fail to accurately predict actual performance, and actual water quality impacts are closer to potential/ pre-mitigation impacts than to predicted/ post-mitigation impacts (they exceed the mine's predicted pollution potential).
    - Project-specific reviews contain over-optimistic and unrealistic predictions, especially of mitigation measure efficacy.
        - Poor results occur despite mines' use of mitigation measures.
- Mitigation technologies and measures typically do not prevent pollution from occurring, particularly in situations where ground water and surface water resources are in proximity to mining-related features and infrastructure.
- Many hyped technologies are experimental, unproven, and are not proven in an environment equivalent to northeastern Minnesota.
- "The BWCAW watershed includes vast, interconnected very high quality waters. In such a watershed existing mining and mitigation techniques cannot be expected to sufficiently reduce the risks to water quality (and other resources) posed by sulfide-ore copper mining. Were mining contaminants to reach waters flowing into the BWCAW it is highly unlikely that existing mitigation measures or technologies could effectively protect water quality and/or be consistent with the BWCAW's wilderness character."

Emmons and Olivier Resources, Inc. **2006. "Cumulative Effects Analysis on Wildlife Habitat Loss/Fragmentation and Wildlife Travel Corridor Obstruction/Landscape Barriers in the Mesabi Iron Range and Arrowhead Regions of Minnesota."** Prepared for the Minnesota Department of Natural Resources, May 15, 2006.

This report presents a cumulative effects analysis performed in 2006 for past, present, and what were at the time reasonably foreseeable actions examined the total land loss and impacts on known wildlife corridors for sensitive species in northeastern Minnesota. It found that six of the 12 remaining wildlife corridors in the 100-mile Mesabi Iron Range will likely become isolated, fragmented, or lost completely, and almost 9,000 acres of habitat will likely be destroyed by mining, economic development, and forestry practices.

Minnesota Environmental Quality Board. **1979. "Minnesota Regional Copper-Nickel Study 1976-1979."** Available < http://www.leg.state.mn.us/edocs/edocs.aspx?oclcnumber=05579755>, accessed 22 April 2017.

When Minnesota faced the first wave of interest in copper-nickel sulfide-ore mining in the 1970s, it undertook a regional-wide study of the impacts that such mining would have on northeastern Minnesota. The study was "commissioned because it was believed that conventional site-specific environmental impact statements (EIS's) and the corresponding regulatory process were inadequate to deal with the broader issues involving this unexploited resource" (Executive Summary, p. i). The resulting 5-volume, 36-chapter study details the study area and the environmental, economic, and social impacts of copper-nickel sulfide-ore mining in the region, and is based on over 180 original technical reports conducted by Environmental Quality Board staff and other experts. Minnesota enacted statewide moratorium on copper-nickel sulfide-ore mining while the study was completed.

Assumptions for the assessments by Dr. Myers, Dr. Baker, Dr. Frelich, Dr. Chambers, Dr. Venturelli, Dr. Vondracek, Dr. Powell, Dr. Fitzpatrick, and Mr. Levit:

- Twin Metals Minnesota deposits would be developed in accordance with the 2014 Technical Report 43-101, Duluth Metals, Inc., with state-of-the-art methods, facilities, and management practices.
- Studies addressed impacts and risks that are likely to occur regardless of changes in mine plans.

Predicted Human Health Impacts and Human Experience and Social Impacts to the Boundary Waters Region of Sulfide-Ore Copper Mining

J. Pearson, et al. **2019. "Risks and costs to human health of sulfide-ore mining near the Boundary Waters Canoe Area Wilderness." (***Human & Ecol. Risk Assessment: An International Journal, https.//doi.org/10.1080/10807039.2019.1576026).* **Peer-reviewed article reviews the health risks and nutritional and social consequences associated with pollutants generally accompanying sulfide-ore copper mining, including air pollutants such as particulate matter and elongated mineral fibers, water pollutants like heavy metals and sulfate, and food chain effects like the build-up of methyl-mercury, and the elimination of wild rice from wild rice waters, both caused by sulfate pollution of naturally low-sulfate waters.**

E. Onello, M.D., et al. **2016. "Sulfide Mining and Human Health in Minnesota."** (*Minnesota Medicine* 2016 (6) 51-55). **This review in Minnesota Medicine, the magazine of the Minnesota Medical Association, addresses from a public health perspective the ways in which sulfide-ore copper-nickel mining in the Duluth Complex is distinct from and potentially more hazardous than Minnesota's traditional iron (taconite) mining.** Key points addressed include:

- Sulfide-ore copper mining may affect public health through the release into the environment of amphibole fibers, fugitive dust, and heavy metals.
- Some of the heavy metals expected to be released from Duluth Complex rock include arsenic, asbestos, cadmium, lead, and mercury, which are identified by the World Health Organization as being of major public health concern.
- Mercury is already a public health threat, as the results of a Minnesota Department of Health study found (one in ten infants in Minnesota's Lake Superior region were born with unsafe amounts of mercury in their blood).
- Sulfide-ore copper mining would exacerbate mercury contamination and bioaccumulation due to the release of additional sulfate – which plays a key role in mercury methylation – into groundwater and groundwater inflows to water bodies.
- A Health Risk Assessment and Health Impact Assessment should be part of any environmental review on the question of future sulfide-ore copper-nickel mining.

Patricia McCann**. 2011. "Mercury Levels in Blood from Newborns in the Lake Superior Basin"** (Nov. 30, 2011) Final Report. Minnesota Department of Health Division of Environmental Health. GLNPO ID 2007-492. **This Minnesota Department of Health study documents that ten percent of newborns in the Minnesota portion of the Lake Superior basin have blood methyl-mercury levels greater than 5.8 ug/L (the U.S. EPA Reference Dose for methyl-mercury), a level associated with loss of IQ.** Fetal blood appears to concentrate methyl-mercury at levels 1.7 times higher than maternal blood. Fetuses, infants, and children are four to five times more vulnerable to the harmful effects of mercury.

Leonardo Trasande, et al. **2005. "Public Health and Economic Consequences of Methyl Mercury Toxicity to the Developing Brain"** *J. Environmental Health Perspectives* Vol. 113: 5(590-596). **This report explains that methyl mercury is a developmental neurotoxicant. Exposure results principally from consumption by pregnant women of seafood contaminated by mercury from anthropogenic (70%) and natural (30%) sources.**

- Blood mercury leads to loss of IQ.
- The loss of intelligence causes diminished economic productivity that persists over the entire lifetime of impacted children.
- The loss of productivity is the major cost of methyl mercury toxicity and amounts to $8.7 billion annually.

May 8, 2017 Comment Letter to the U.S. Forest Service and BLM from health professionals and health professional organizations **expressed concerns about impacts to human health posed by sulfide-ore copper mining.**

- Sulfide-ore mining releases at least 6 of the 10 environmental toxins listed by the World Health Organization with greatest concern to human health.
- Environmental studies of sulfide-ore copper mining in the Rainy River watershed should include independent, scientifically rigorous, and comprehensive health risk assessment (HRA) and health impact assessment (HIA) for:
    - Those who live in downstream communities.
    - Those who visit the Boundary Waters Canoe Area Wilderness and surrounding communities who will be drinking downstream waters.
    - Fetuses, infants, and children, those most vulnerable to the deleterious effects of methylmercury.
    - Low-income and tribal communities who rely on hunting, fishing and gathering of wild rice and other plants for their subsistence and cultural well-being.
- The HRA and HIA should
    - Assess cumulative mercury risks, including hazard levels in bodies of water that may already be impaired for mercury in fish.
    - Assess cancer and non-cancer risks to future on-site workers.
    - Assess health risks resulting from fossil fuel combustion.
    - Assess cumulative risks of multiple chemicals.
    - Assess noise pollution to the surrounding wilderness.
- The HIA should rigorously scrutinize the social determinants of health in this sensitive and unique region of Minnesota, including
    - The cost for health care, special education, lost productivity resulting from potential human health impairments.
    - The cost and capability of increasing mental health providers in the Boundary Waters Region to meet increasing needs.
    - The cost of the potential loss of a pristine wilderness that serves as a source of mental and spiritual health not only for the local region, but for countless individuals across Minnesota and the nation.
    - The cost of potential erosion of the pristine wilderness that has sustained an outdoor recreation industry in Minnesota that contributes to a stable tax base, jobs in a range of sectors, and the retention of talent and wealth in Minnesota.

In a subsequent Comment Letter dated February 2018, four medical professionals **restated many of these concerns, and added that mining in the Superior National Forest adjacent to the Boundary Waters would be expected to cause degradation of the air quality in a large portion of the Boundary Waters Canoe Area Wilderness, endangering on-site workers, members of nearby communities, and visitors to the area.** The harm would be insidious, potentially causing disease years after injury occurred. The Boundary Waters Canoe Area Wilderness is a Class 1 airspace under the Clean Air Act.

- The medical professionals asked that the Mineral Withdrawal EA study the risks and costs of the loss of wellness that will result if communities around the Boundary Waters were to transition from communities that serve as the gateway to pristine wilderness, to communities that are a gateway to large industrial mine sites.
- The medical professionals urged that the EA "include not only the potential deleterious effects of sulfide-ore copper mines in this water-rich area, but also include an assessment of the benefits of the current region AS IT IS and the risks/costs of what will be lost with the development of sulfide-ore copper mines at the headwaters of the Boundary Waters. They state that a robust EA that includes these components will demonstrate that the mineral withdrawal in the Rainy River watershed is necessary to protect the health and wellness of this sensitive and special region of our state.
- The Comment Letter confirmed that 30,000 health professionals have expressed grave concern about opening SNF lands in the watershed of the Boundary Waters Canoe Area Wilderness to sulfide-ore copper mining and collectively call for a HRA and a HIA.

Jane Reyer, J.D. and Rachel Garwin, M.S. **2015. In "The Impacts of Mining on the Character of a Wilderness Landscape: Considerations for Federal Decision-Making" Reyer and Garwin pose the question "How will this change in land use affect people's life experience," noting that "[s]ome places … are so important to people's sense of what is right and good and of ultimate value that the character of the area becomes…a critical consideration in decisions about land use changes that will affect that character.** The Boundary Waters Canoe Area Wilderness and the Birch Lake/ South Kawishiwi River that flow into it are such a place. To transform this area from what it is today into an industrial mining district would amount to a change in the character of a landscape that would affect the experience and psychological well-being of tens – or even hundreds – of thousands of people in a way that simply cannot be captured by a discussion of ecological and economic considerations." The authors show that

- Changes of the nature required by mining would affect something fundamental to peoples' sense of well-being.
    - "Any government decision that allows mining to move forward in this area [South Kawishiwi River and Birch Lake] is in part a decision to sacrifice a landscape that nourishes people's souls to the most destructive industry that humans have devised."
- Industrial-scale mining is probably the single activity that has the greatest potential for impacting wilderness character when it is undertaken outside of but in close proximity to a wilderness area. There simply is no other activity that creates the amount of disturbance, noise, light pollution, traffic, human presence, and pollution in remote locations. Mining close to a wilderness area would inevitably impact wilderness character.
- There is legal support for making this a primary consideration of any decisions that would result in a transformation of Superior National Forest lands adjacent to the Boundary Waters Canoe Area Wilderness into an industrial mining district.
    - Congress has directed the U.S. Forest Service to protect wilderness character and to protect the Boundary Waters Canoe Area Wilderness from mineral development to the maximum extent possible and has provided no countervailing directives that would provide a rationale for permitting a mine if the Boundary Waters Canoe Area Wilderness would be affected.
- There are historical examples of federal agency decisions that took similar considerations into account.
    - In Yellowstone National Park, the Grand Canyon National Park, and the Rocky Mountain Front of the Lewis $ Clark National Forest decisions were made to protect the character of the landscape, even though it meant that the metal or oil found there would not be made available for human use.
- Ecological risk assessments provide a context for such considerations in a NEPA analysis
- Several inevitable impacts of industrial mining that would result in the transformation of the character of the South Kawishiwi area and would significantly impact the wilderness character of the adjacent Boundary Waters Canoe Area Wilderness.
    - Outside the Wilderness what is now a beloved recreation area would become an industrial landscape.
    - Inside the Wilderness the proximity of industrial activity would mean that this part of the wilderness area would no longer be experienced as wilderness.
- "Perhaps more than for any other wilderness in the country, American citizens have stood up again and again to fight to retain the wilderness qualities of the Boundary Waters Canoe Area Wilderness. They have done so because the BWCAW speaks to them in a way of no other place they have known. Mining on the edge of the wilderness would ensure that this part of the BWCAW would no longer bring the deep joy that so many come here to find."

Center for Small Towns & Data Services Center. **2014. "The Four Townships Area Economic, Housing and Development Survey."** University of Minnesota Morris. In 2014, the Center for Small Towns & Data Services Center at the University of Minnesota Morris released a report on their survey of all property owners in the four townships surrounding Ely.

- When asked, "Why do you choose to live or own land in the four townships area?" respondents overwhelmingly highlighted natural amenities.

- Conversely, when asked what would make them leave the four townships area, respondents chose "mining," "pollution" and "overdevelopment" as the top three of four categories.
    - **23% of the respondents said they would leave the area if mining were developed.**
- Likewise, the Minnesota Design Team visited Ely in 2014. They gathered 200 residents for a community visioning session to help guide Ely's future. In response to the question, "What do you love most about your community?" the common response was, "Location near wilderness – Boundary Waters." In addition, residents surveyed saw "tech-based businesses via broadband internet" as Ely's next economic opportunity, not mining.

Minnesota Department of Health, Minnesota Climate & Health Program, Environmental Impacts Analysis Unit. 2014. **"Minnesota Climate Change Vulnerability Assessment 2014: Executive Summary**." At < http://www.health.state.mn.us/divs/climatechange/docs/mnclimvulnreport.pdf>, accessed 22 April 2017.

Minnesota Department of Health conducted the Minnesota Climate Change Vulnerability Assessment from 2013-2014, and this executive summary and full report presents the findings. The five climate hazards listed as primary threats to Minnesota at large include extreme heat, vector-borne diseases, flooding and flash flooding, and drought.

Minnesota Department of Health, Minnesota Climate & Health Program, Environmental Impacts Analysis Unit. 2015. **"Minnesota Climate and Health Profile Report 2015."** Available <http://www.health.state.mn.us/divs/climatechange/docs/mnprofile2015.pdf>, accessed 22 April 2017.

Minnesota Department of Health presents a comprehensive assessment of climate change effects, trends, and projections; describes how the changes are linked to potential health impacts; and the resulting burden for the state. Health hazard pathways described include air pollution, extreme heat, floods and drought, and ecosystem change-related threats to human health.

Predicted Economic Impacts to the Boundary Waters Region of Sulfide-Ore Copper Mining

James H. Stock, Ph.D. and Jacob Bradt, **2018. An independent study by prominent Harvard economist Professor James Stock compares the effects of the Forest Service's proposed 20-year mining ban near the Boundary Waters with the consequences of sulfide-ore copper mining in the Boundary Waters watershed. The conclusion: protecting public lands near the Boundary Waters generates greater long-term gain for the region (more employment and income) than copper mining.**

- The study compares two scenarios being considered by federal agencies:
    - Scenario 1 – The Boundary Waters economy continues to develop during a 20-year mining ban.
    - Scenario 2 – The mining ban does not occur, and a Twin Metals/ Antofagasta mine is developed.
- The study projects 36 employment and 72 income scenarios representing a range of employment and income effects. The analysis shows that over a 20-year period, an economy based on copper mining would significantly underperform the growing, sustainable economy already in place. Compared to a Twin Metals/ Antofagasta mining economy, the proposed mining ban would result in:
    - 1,500 to 4,600 more jobs
    - $100 million to $900 million more income
- This is the only economic study to analyze the longer-term dynamic economic effects of the two options over a 20-year timeframe.

Spencer Phillips, Ph.D. and Carolyn Alkire, Ph.D. **2017. In their report, "Sulfide-Ore Copper Mining and/or A Sustainable Boundary Waters Economy: The Need to Consider Real Tradeoffs" Drs. Phillips and Alkire describe the key indicators of transition and economic growth in the diversifying and more stable modern economy that exists in**

the three-county Arrowhead Region, which has developed in the years since the start of mining's decline in the early 1980s. In the modern Arrowhead economy, amenity-based development has taken the place of mining as the engine of development in the region. The authors describe amenity-based development as:

> "economic activity connected to a region's scenic, recreational, environmental (clean air, clean water), and other quality-of-life assets. Amenity-based development extends far beyond the recreation and tourism industries to any good- or service-producing industry that sells homes, cars, personal or professional services, food, etc. to people who move to, or stay in, a region because of its scenic beauty, quality of life, and in the case of the Boundary Waters, unique, world-renowned recreational opportunities."

The authors further describe how a mineral withdrawal of 234,328 acres in the Superior National Forest (Withdrawal Study area) would avoid economic costs associated with actual and potential sulfide-ore copper mining that, absent the withdrawal, could proceed in the Withdrawal Study area. These estimated costs include

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

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

The authors also recommend a set of studies, valuations, and surveys that the U.S. Forest Service should include in the economics section of the Environmental Impact Statement. These include:

- a systemic survey of business owners and managers in all sectors to estimate the effect of potential sulfide-ore copper mining on the outlook for Minnesota, and especially the Arrowhead Region.
- a thorough, statistically valid survey of residents, visitors, vacation and second homeowners, and other stakeholders' decisions about whether to vacation, retire, locate, or stay in the region under alternative scenarios.
- a hedonic price survey of residential, commercial, and other property values in areas where similar mining operations have occurred.
- an examination of the extent to which forecasted mining employment at lower- and higher-wage positions would be available to and occupied by current Arrowhead residents.
- an evaluation of the proposed action's avoided effects on all ecosystem services (timber production, fish and game and plant foods, water for drinking, recreational opportunities as valued by impacts and benefits, and other ecosystem benefits).
- an estimate of impacts to passive-use value.

S. Phillips, Ph.D. **2018. In his most recent report, Dr. Phillips says that claims of increased mining employment must be viewed in light of an accelerating trend of decreasing labor intensity in the mining industry.**

- A new wave of automation in mining uses autonomous and remotely controlled machinery monitored by a few persons who may be located far from mining sites.
- This continuing trend means that estimates made now of the number of jobs a mine may have to offer in the future are inflated and are not likely to be local jobs for local people.

- Copper mining giant Anglo America predicts automation will make the future mining industry "unrecognizable" to people who know it now and the human employee of the future will only need to focus on managing the company's community relations.
- In contrast "…the mining withdrawal could save between 9,556 and 27,281 jobs."

***S. Phillips, Ph.D.* 2014. "The Boundary Waters Canoe Area...Wealth Generator."**

Dr. Spencer Phillips sought to characterize the existing economy in the Boundary Waters Region, defined as the three counties surrounding the Boundary Waters Canoe Area Wilderness. He found that the Boundary Waters is an important driver of wealth and supports the local and regional economy. Specifically, the report states that the natural amenities of the Boundary Waters and surrounding Superior National Forest provide a critical component to a thriving rural economy, and that property values increase with proximity to a wilderness area. Dr. Phillips also examined likely negative economic impacts from allowing sulfide-ore copper mining to proceed within the Boundary Waters watershed, including displacing the existing economy supported by natural amenities, tourism, forestry, and recreation. Erratic boom and bust cycles associated with mining would have economic costs, as well, as they would create instability in the labor markets and increase strain on public services.

***T. Power, Ph.D.* 2007. "The Economic Role of Metal Mining in Minnesota: Past, Present, and Future**."

Dr. Thomas Power's report investigates the economic role of metal mining in Minnesota within the context of metal mining across the country and over time. He found that economic benefits of proposed sulfide-ore copper mining would be uncertain at best. Automation and other laborsaving technology have greatly reduced the need for workers in new sulfide-ore mines. From 1972 to 2007, while US copper production fluctuated above and below 1.5 million metric tons, the number of copper-mining jobs dropped by 71%. Similar trends occurred in the Minnesota taconite-mining sector between 1979 and 2005, where labor productivity tripled and production declined modestly, resulting in 73% fewer Minnesota taconite-mining jobs. Employment would still have declined by 67% even if production had remained constant. Of special concern to the Boundary Waters region is Power's statement, "For adjacent communities that do not have diversified economies and rely heavily on mining, this pattern of labor-displacing technological change means regular layoffs and relatively high unemployment rates, even when high levels of production are maintained" (p. 6).

***E. Hjerpe, Ph.D.* 2017. "Regional Economic Impacts of Boundary Waters Wilderness Visitors."**

This study quantified out-of-region Boundary Waters visitor spending in summer 2016 created nearly 1,000 full and part-time jobs in the three county Boundary Waters Region. These visitors spent nearly $57 million in the three counties, generating $77 million in economic output.

***Timberjay.* 2017. An economic analysis published by the Timberjay on August 3, 2017 provides an in-depth look at some of the potential economic costs associated with a proposed sulfide-ore copper mine in the Ely area.**

This conservative analysis is a case study of one specific mine proposal, the Twin Metals mine, and the economic impact it would have on income generated by local residents in the Ely area (Ely and the four neighboring townships). The study concludes that the opening of a Twin Metals mine could lead to an initial loss of anywhere from $22.9 million to $28.6 million in local income, a figure that will likely increase over time. This economic loss of local income would exceed any gain in local income from a Twin Metals mine.

Sun, B. **2013. "Land use conflict in an iron range community: an econometric analysis of the effect of mining on local real estate values and real estate tax collections."** Oral Presentation, University of Minnesota-Morris.

> An econometric study of a gold and silver mine's effect on local real estate values in Fairfield County, South Carolina, showed that property sale prices decreased with increasing proximity to the mine.

E. Hjerpe, Ph.D. and S. Phillips, Ph.D. 2013. A Review of "The Economic Impact of Ferrous and Non-Ferrous Mining on the State of Minnesota and the Arrowhead Region."

> An expert critique of an industry-funded economic study that is widely used to promote positive economic impact from bringing every single proposed sulfide-ore copper mine in northeastern Minnesota online. Drs. Hjerpe and Phillips (natural resource economists) reviewed the study and found that it inappropriately included all ongoing ferrous and non-ferrous mining operations in addition to future construction and operation, resulting in an overstated total economic impact. Additionally, they found, "Inclusion of existing operations indicates a lack of understanding economic impact analysis and grossly exaggerates impacts. In reality, such rapid mining expansion would come at the loss of existing mining industry due to increased cost of supply inputs and decreased market prices of final products from flooded local markets" (p. 7). Finally, the job increases projected in the study were to be realized by 2016 (instead mining jobs declined). Over 90% of the projected job gains were to be in the taconite industry; less than 10% were projected for the copper industry.

<u>Performance Record of Hardrock Mining and Potential Impacts to the Boundary Waters Region</u>

Earthworks summarized the state of current US copper mining environmental impacts **in its peer-reviewed report "U.S. Copper Porphyry Mines: The Track Record of Water Quality Impacts Resulting from Pipeline Spills, Tailings Failures, and Water Collection and Treatment Failures"** (July 2012, revised November 2012). Earthworks found:

- Of fourteen sulfide-ore copper mines representing 89% of U.S. copper production found that 100% of the mines studied had experienced pipeline spills or other accidental releases, and 92% (13 of 14) had experienced water collection and treatment failures resulting in significant effects on water quality.
- Leaks occur at all mines.
- Although the likelihood of a particular type of leak cannot be predetermined (and this is true even with a detailed, comprehensive mine plan), the probability of some type of leak is high.

L.N. Bowker and D.M. Chambers. **2015. "The Risk, Public Liability, & Economics of Tailings Storage Facility Failures."** Bowker Associates, Science and Research in the Public Interest, Stonington, ME, and Center for Science in Public Participation, Bozeman, MT.

> **Lindsay Newland Bowker, CPCU, ARM, and Dr. David Chambers, professional engineer, examined 100 years of tailings storage facility failures and found that despite industry assurances to the contrary, the risk of serious and very serious failures is increasing.** While technological advances have allowed miners to economically recover increasingly lower grade ore, the design of storage facilities for waste rock, tailings and waste water has not kept pace with the increasing volume of waste that must be stored in perpetuity. Additionally, the tight bottom lines faced by companies extracting poor quality ore at low metal prices contributes to the challenge of maintaining tailings storage facility integrity since the techniques that reduce risk are often prohibitively expensive. Bowker and Chambers found that 49% of all recorded "serious" and "very serious" failures between 1940-2010 occurred since 1990. Included were failures at operating mines and mines in the U.S. and Europe. These failures are large enough to cause serious damage, involve loss of life, or contribute other types of significant social or economic damage, which can be non-remediable. They project that with increasing numbers

of mining projects extracting increasingly low-grade ore the rate of serious or very serious tailings storage facility failures will increase, which will carry catastrophic results.

***D.M. Chambers.* 2015. A Review of the "Report on Mount Polley Tailings Storage Facility Breach, Independent Expert Engineering Investigation and Review Panel."** Center for Science in Public Participation, Bozeman, MT.

Dr. Dave Chambers of the Center for Science in Public Participation reviewed the report on the 2014 tailings storage facility failure at the Mount Polley copper mine. Dr. Chambers summarized the causes of the dam failure and the ineffective monitoring technologies that failed to warn anyone that a catastrophic failure was about to occur. Dr. Chambers also emphasizes the panel's conclusion that the industry must work toward a goal of zero tailings dam failures, which is not currently the industry's goal.

***D.M. Chambers, and B. Higman.* 2011. "Long Term Risks of Tailings Dam Failure."** Center for Science in Public Participation, Bozeman, MT, and Ground Truth Trekking, Seldovia, AK.

Report describing the high risks of long-term storage of tailings using large dams since they must remain intact forever, and yet have a higher incidence of failure than water reservoir dams. The authors argue that since technology and science have limits, policy makers should use a more conservative approach to making decisions about long-term risk than currently used.

***Earthworks.* 2013. "Polluting the Future: How mining companies are contaminating our nation's waters in perpetuity."**

This report from Earthworks documents the extent to which perpetual pollution from hard rock mining in the United States has contaminated vast amounts of the nation's fresh groundwater – an increasingly valuable and scarce essential resource. An estimated 17 to 27 billion gallons of water will be polluted by just 40 mines every year in perpetuity, and yet no open pit hard rock mine in existence today has demonstrated the ability to stop acid mine drainage once it has begun on a large scale.

***D. Giurco, and J.G. Petrie.* 2007. "Strategies for reducing the carbon footprint of copper: New technologies, more recycling or demand management?"** *Minerals Engineering* 20: 842-853. doi:10.1016/j.mineng.2007.04.014

In this peer-reviewed journal article, the authors conducted a life-cycle analysis of mined copper to estimate the copper industry's CO_2 contribution and climate change impacts. The carbon emissions from primary mined copper is expected to increase over time, due to the decreasing quality of ore and increasing amount of industrial effort and energy necessary to extract and process the ore. A case study of US copper production demonstrates the importance of improving recycling techniques and share of the copper market to reduce the industry's carbon impact.

***J.R. Kuipers, Maest, A.S., MacHardy, K.A., and Lawson, G.* 2006. "Comparison of Predicted and Actual Water Quality at Hardrock Mines: The reliability of predictions in Environmental Impact Statements."** Kuipers & Associates, Butte, MT, and Buka Environmental, Boulder, CO.

The research team compared the predictions of water quality impacts from hardrock mines made during the environmental review phase to actual water quality impacts that occurred at hardrock mines once they were built. They studied a representational sample of hardrock mines subject to environmental review under the National Environmental Policy Act in order to create a comprehensive picture of the predicted versus actual water quality impacts. Of the case study mines, sixty percent caused surface water quality exceedances, and at the majority of the mines, impacts occurred despite predictions that no impacts would occur after mitigation

efforts were put in place. Of the case study mines, most mines predicted no groundwater quality impacts after mitigation was in place, but impacts occurred in a majority of the cases. The effectiveness levels of mitigation measures were consistently overestimated, leading to unexpected surface water and groundwater impacts. Finally, "nearly all of the mines (8/9) that developed acid mine drainage either underestimated or ignored the potential for acid drainage in their EISs" (p. ES-8).

The research team also found that "Some mine projects are so high risk that water quality exceedences are a near certainty: those mines that are both near groundwater or surface water resources and possess an elevated potential for acid drainage or contaminant leaching.

- 85% of the mines near surface water with elevated potential for acid drainage or contaminant leaching exceeded water quality standards
- 93% of the mines near groundwater with elevated potential for acid mine drainage or contaminant leaching exceeded water quality standards
- Of the sites that did develop acid drainage, 89% predicted they would not."

"Of the 19 mines that exceeded water quality standards, the pollutants that exceeded standards were as follows:

- Toxic heavy metals such as lead, mercury, cadmium, copper, nickel or zinc exceeded standards at 63% of mines.
- Arsenic and sulfate exceeded standards at 58% of mines.
- Cyanide exceeded standards at 53% of mines."

B. Loechel, J. Hodgkinson, and K. Moffat. **2013. "Climate change adaptation in Australian mining communities: Comparing mining company and local government views and activities."** *Climatic Change* 119(2): 465-477. doi:10.1007/s10584-013-0721-8

Future climate change impacts will increase the uncertainty around whether mining infrastructure, including tailings storage facilities and process water ponds, will retain their structural integrity over time. To avoid catastrophic failure, mining companies must plan for an uncertain future that includes increased severity and frequency of extreme weather events. This study surveyed mining companies and local governments in Australia to assess the mining companies' and governments' perception of future impacts from climate change. The authors found a striking lack of concern for future impacts, "suggesting discounting of risks due to climate change skepticism." While specific to Australia, this study demonstrates how personal and industry attitudes toward climate change can increase the risk of catastrophic impacts from mines built without considering necessary adaptation techniques.

M. Rico, G. Benito, A.R. Salgueiro, A. Díez-Herrero, and H.G. Pereira. **2008. "Reported tailings dam failures: A review of the European incidences in the worldwide context."** *Journal of Hazardous Materials* 152: 846-852. doi:10.1016/j.jhazmat.2007.07.050

The research team compiled records for European tailings dam failures within the context of tailings dam failures around the world in an effort to describe the distribution of tailings dam failures and identify risk factors. Out of 147 identified tailings dam failures around the world during an unspecified period of time, 57 occurred in the United States. The paper reports another index of tailings dam incidents that recorded 185 tailings dam incidents in the United States between 1917-1989, and many additional tailings dam incidents were known to occur after 1990.

***E.J. Sherlock.* 1995. "Evaluation of Static and Kinetic Prediction Test Data and Comparison with Field Monitoring Data"** (MAS thesis). Retrieved from MEND database. MEND Project 1.16.4.

This master's thesis compared methods of predicting acid mine drainage potential with actual field data for a tailings impoundment once it was developed. Sherlock found that there can be great variability in acid generation predictions, and that the predictions depend on many factors that can lead to incorrect predictions. For instance, sites predicted to have "no acid generating potential" often use short-term studies that do not consider the extended length of time material will be exposed to oxidizing conditions. In one case, it took three years of continued kinetic testing of tailings in humidity cells for acid rock drainage conditions to manifest, and many kinetic tests during environmental review processes do not allow such long-term testing.

Related Ecological Studies and Potential Impacts to the Boundary Waters Region

W.M. Daniel, D.M. Infante, R.M. Hughes, Y.P. Tsang, P.C. Esselman, D. Wieferich, K. Herreman, A.R. Cooper, L. Wang, and W.W. Taylor. 2014. "Characterizing coal and mineral mines as a regional source of stress to stream fish assemblages." Ecological Indicators 50: 50-61.

In 2014, a team of researchers from Michigan State University, Oregon State University, the USGS Great Lakes Science Center, and the International Joint Commission Great Lakes Regional Office published a study in the peer-reviewed *Ecological Indicators* journal that showed the potential for mines to be sources of regional stress on fish assemblages (groups of fish that co-occur in an ecosystem) over large spatial scales. Daniel et al. built on an established body of research showing local negative impacts to fish habitats, fish species diversity, and fish size and survival in streams and their immediate basins in close proximity to coal and mineral mines. This team, however, broadened their inquiry to assess relationships between mine density and indicators of fish assemblage health on a regional scale, across multiple streams and catchments. While this study did not address mines in northern Minnesota, it did look at three broad ecoregions (Northern Appalachian Ecoregion, Southern Appalachian Ecoregion, and Temperate Plains Ecoregion) and showed consistent trends of negative, cumulative impact from mines to fish assemblages across all of them at the regional/multi-catchment scale.

***D.C. Evers, L.J. Savoy, C.R. DeSorbo, D.E. Yates, W. Hanson, K.M. Taylor, L.S. Siegel, J.H. Cooley Jr., M.S. Bank, A. Major, K. Munney, B.F. Mower, H.S. Vogel, N. Schoch, M. Pokras, M.W. Goodale, and J. Fair.* 2008. "Adverse effects from environmental mercury loads on breeding Common Loons."** *Ecotoxicology* 17: 69-81. http://dx.doi.org/10.1007/s10646-007-0168-7

This research team studied groups of loons in New Hampshire and Maine to determine the effects of methylmercury loads on the breeding success of Common loons. **They found that the loons at highest risk for environmental mercury contamination had 41% fewer fledged young than the reference group of lower risk loons, demonstrating the negative impacts methylmercury can have on loon populations.**

***S.R. Jenning, D.R. Neuman, and P.S. Blicker.* 2008. "Acid Mine Drainage and Effects on Fish Health and Ecology: A Review."** Reclamation Research Group Publication, Bozeman, MT.

This review paper describes the ways that acid mine drainage (AMD) negatively affects fish health and ecology. Oxidation and hydrolysis reactions turn formerly stable minerals into toxic materials, including acid, metals (e.g., mercury, copper, cadmium, nickel, lead, arsenic, and zinc), and sulfates (react to form sulfides). Acidic conditions further catalyze these reactions, making them proceed at faster rates than would otherwise occur. AMD can affect fish populations and aquatic ecosystems both through direct toxicity and by indirect effects on the food chain and habitat availability. For instance, high acidity (low pH) can alter gill membranes and cause hypoxia among fish, and pH below 6.5 can have negative effects on fish reproductive success. Indirect

effects to fish include direct toxicity to food sources (e.g., insects and other macroinvertebrates that live in streambeds), reduction of habitat, and coating of gravel beds used for spawning. Episodes of acute toxicity can kill thousands of fish in a number of minutes, as occurred in 1989 when a thunderstorm event caused enough acidification and elevated copper concentrations within 20 minutes to kill over 5,000 salmonids in Montana's Clark Fork River.

D.C. Tozer, C.M. Falconer, and D.S. Badzinksi. **2013. "Common Loon reproductive success in Canada: the west is best but not for long."** *Aviation Conservation and Ecology* 8(1): 1. http://dx.doi.org/ 10.5751/ACE-00569-080101

> **This long-term study of loons in Canada emphasizes their importance at the top of the food chain, and the threats they face from methylmercury. The** Common Loon is a "powerful indicator of local aquatic system health, especially in relation to mercury and acid precipitation" (p. 1). Elevated methylmercury levels create neurological and physiological problems for loons, including increased lethargy, reduced food-seeking behavior, and reduced ability to avoid predators (Tozer et al. 2013). Data collected over 18 years across Canada showed a relationship between smaller lakes with higher methylmercury exposure and low pH and reduced loon reproductive success, and the study suggested that "mercury and acid precipitation are among the most important drivers of Common Loon reproductive success in southern Canada" (p. 9).

Best Practices for Siting Mines in Ecologically and Culturally Significant Areas

Robert M. Hughes, Felipe Amezcua, David M. Chambers, Wesley M. Daniel, James S. Franks, William Franzin, Donald MacDonald, Eric Merriam, George Neall, Paulo dos Santos Pompeu, Lou Reynolds & Carol Ann Woody**. 2016. "2016 AFS [American Fisheries Society] Position Paper and Policy on Mining and Fossil Fuel Extraction, Fisheries,"** 41:1, 12-15, DOI; 10.1080/03632415.1121742; http://dx.doiorg/10.1080/03632415.2016.1121741.

> **This paper recommends substantive changes in how North American governments conduct environmental assessments and permit, monitor, and regulate mine and fossil fuel development. AFS recommends that a formal environmental impact statement should be done first, and following such a study, the public should be involved in deciding whether a mine…is the most appropriate use of land and water, particularly relative to the need to preserve ecologically and culturally significant areas.**

Failure of Minnesota to Regulate Mining

WaterLegacy De-delegation petition. **2015.** Minnesota is the primary authority for state water quality, charged under the Clean Water Act with issuing permits for point-source discharges of pollutants into the state's surface waters. These permits, called National Pollutant Discharge Elimination System permits, must contain discharge limits designed to maintain water quality standards set by the State. **This well-documented de-delegation petition asks the EPA to remove Minnesota's delegated authority to issue permits for mining under the Clean Water Act for failure to uphold state and federal laws protecting Minnesota water quality.**

- Minnesota cannot be counted on to carry out its obligations to protect Minnesota's water quality