



Natural Resources Research Institute  
2017 Annual Report





Josh Dumke, Holly Wellard Kelly and Valerie Brady (left to right) show Rolf Weberg a tool developed at NRRI to capture spiny water fleas in local lakes. The research project is focusing on the role of fishing equipment in the spread of aquatic invasive species.

Welcome to our 2016-17 fiscal year report. NRRI enjoyed a productive and exciting year and we are pleased to share highlights with you. However, on behalf of all our staff, I would first like to extend our sincere thanks to our many supporters and partners across Minnesota who have helped and encouraged NRRI to continue to drive forward.

To deliver on our mission, NRRI is focusing our work around three themes:

- Reduce waste and increase yield from the resources we use.
- Diversify product offerings for greater resilience and to drive higher value keeping more of Minnesota's resource wealth in the state.
- Embrace sustainable resource practices and value our natural ecosystems as a competitive advantage for Minnesota products.

As a result, I can point to innovations and results across our portfolio of initiatives. Our water scientists continue to build a solid foundation of basic data that helps define research across the Institute. In partnership with many collaborators, NRRI is demonstrating new opportunities in mineral resources and mineral processing strongly linked to programs on water quality. Our forestry team is developing new technologies to understand Minnesota's forest resources while our wood products and bioeconomy teams work to unlock the hidden value in wood and other biomass feedstocks. We commissioned a pilot plant at our Coleraine facility to convert waste woody biomass into high value solid fuels and look forward to continued expansion of that asset. With support from the Blandin Foundation, and in collaboration with UMD's Center for Economic Development and the Itasca Economic Development Corporation, NRRI introduced the Business Assistance Fund to offer technical development help to the business community and entrepreneurs.

A key event in 2017 was an increase in NRRI's state base funding which had remained unchanged since the mid-1980s. Without that increase, the Institute was unsustainable. Thanks to broad support and collaboration between University of Minnesota leadership, the legislature, the Governor's office, agency partners and our state stakeholders, the need was answered. Today we are reinvesting in our team, attracting new talent and building skill sets that focus on the future.

I invite you to read through our report. In doing so, I hope that you feel the return on Minnesota's investment in NRRI. We look forward to your feedback and questions - and stand ready to welcome you to visit NRRI where our research goes to work for you.

Rolf T. Weberg  
Executive Director, Natural Resources Research Institute

NRRI is a strategic, mission-driven, applied research organization focused on delivering solutions that drive economic prosperity, environmental stability, and resilient communities. Among national institutes, NRRI is the leader in the sustainable economic development of natural resources. NRRI's extensive capabilities, facilities, relationships and collaborations provide a unique and effective research platform.

## MISSION

Deliver research solutions to balance our economy, resources and environment for resilient communities.

## VISION

NRRI promotes entrepreneurship, job creation, economic diversification and resource stewardship for resilient, vital communities. Our people are recognized and sought out as premier applied researchers focused on economic development of natural resources balanced with environmental protection and restoration. We actively engage stakeholders to anticipate and characterize challenges, define research directions, drive targeted discovery and deliver system-based solutions. We promote balanced decisions that consider the needs of today and those of future generations. We collaborate with regional and global partners.

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Red pine growing tall in the University of Minnesota's Cloquet Forestry Center.

## INFORMING MANAGEMENT OF RED PINES

Waiting too long to thin red pine stands is a problem. It makes the trees susceptible to wind blow-downs, snow damage and insects.

NRRI published a guide for forest managers who are confronting a lot of stands ready for their first thinning. It was published in June 2017, and released by the Minnesota Department of Natural Resources.

Red pine is a very versatile tree species that can be grown for a variety of products. It also grows without much encouragement. The goal is to have properly managed working forests that are healthier and less of a fire risk than unmanaged, overgrown forests. By opening the canopy and allowing for native understory plants, red pine regrowth is already on its way when the stands are harvested.



Paul Meysembourg prepares to launch a UAV toward an aspen plot near Cloquet, Minn.

## APPLYING NEW TECHNOLOGIES TO FORESTRY

NRRI is using Light Detection and Ranging technologies (LiDAR) and Unmanned Aerial Vehicles (UAVs) with multi-spectral cameras to provide highly accurate information to forest managers. The captured data allows NRRI's forestry experts to estimate tree age and density to predict timber volume with unprecedented ease and accuracy.

The cameras on drones (UAVs) capture images in green, infrared, near-infrared and red-edge to reflect changing colors in plants. This allows foresters to see where there's water stress, insect invasions or nutrient deficiencies. They can also quickly and inexpensively track tree growth and monitor harvests.

## PROJECT UPDATE: PEAT PATENTS APPROVED

Patents were received in 2017 for two specialized wastewater treatment products based on Minnesota peat resources. One of the granulated peat products targets the removal of cadmium, copper and zinc from mine water systems. The second targets the removal of cadmium in the presence of zinc. These new filter systems can be used directly on mine and wastewater without any pretreatment, even with the presence of particulates. The filter products are being commercialized by American Peat Technologies in Aitkin, Minn. NRRI Chemist Igor Kolomitsyn will continue to partner with the company to develop more specialized products.



Peat granules after modification.

## NEW RESEARCH INVESTIGATES AQUATIC INVASIVE SPECIES

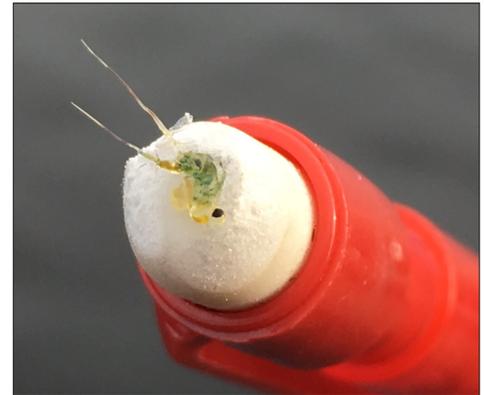


From left, Matt Santo, Kari Hansen and Holly Wellard Kelly capture spiny water fleas. At right: A spiny water flea on the tip of a pencil eraser.

In June NRRI was awarded funding for two aquatic invasive species projects that assess impacts of spiny water flea and zebra mussels.

One project, led by NRRI's Katya Kovalenko in partnership with Minnesota Department of Natural Resources will determine the effects on lake food webs and game fish from double invasion by zebra mussels and spiny water flea.

The second project, led by NRRI's Val Brady and Donn Branstrator of Minnesota Sea Grant, seeks to better understand how spiny water flea are spread to slow their invasion.



## KEEPING IT COOL FOR NORTH SHORE TROUT

The need to better understand North Shore trout streams in the face of climate change spurred funding from Trout Unlimited and the Environment and Natural Resources Trust Fund in 2016. NRRI tapped volunteers and pulled together a work crew that set about taking the temperature of 121 stream segments. This ongoing project will identify the locations of groundwater discharge to target trout habitat restoration and protection efforts.

Results so far show that 83 stream segments contain cool water locations. Warming water is the greatest threat to trout and steelhead fisheries. Streams with more cold water refuges will protect populations as temperatures rise. NRRI researchers resampled the stream locations during the summer of 2017 to validate model predictions.



Kari Hansen notes data while Nick Pierce takes a temperature reading from a small stream in rural Duluth.

# Business Assistance Fund Helps Entrepreneurs

NRRI provides support to businesses to drive success and boost Minnesota's economy

Entrepreneurs are important innovators and economic drivers. And that's especially needed in Minnesota's rural communities. But, starting and owning a small business is challenging.

NRRI Business Assistance Fund, a collaborative effort with an infusion of funding from sources including the Blandin Foundation and U.S. Department of Agriculture Forest Services, provides business assistance with technical research and development to drive entrepreneurial success.

Successful applicants to the Business Assistance Fund will receive upfront planning and analysis assistance from UMD's Center for Economic Development and hands-on technical research assistance from NRRI.

Blandin Foundation support of \$150,000 will target entrepreneurs in Itasca County, plus the rural communities of Hill City, Remer, Blackduck and Northome. Successful applicants would be awarded amounts in the \$500 - \$25,000 range, to be matched by the applicant. The USDA grant of \$25,500 is for innovations in the forest products industry. It supports small business efforts to develop ideas that will increase the use of low value wood in areas of high wildfire risk, reducing the cost of forest management.

NRRI is actively looking for more funding opportunities to expand the scope of its Business Assistance Fund in order to support more entrepreneurs and boost Minnesota's economy.

Applications are accepted online at [nrri.umn.edu](http://nrri.umn.edu). Applicants should identify clearly how their needs complement the expertise and technologies available at NRRI.

"The support businesses and entrepreneurs get from this grant will allow them to reach market faster, with less risk and less cost," said Hosseinpour.

NRRI researchers and scientists put special emphasis on helping companies use their resources efficiently with less waste and higher value. The institute has laboratories



and expertise in the areas of technology development, testing and analytical services; lean manufacturing and productivity training; environmental characterization, materials sourcing, business planning and much more.

"Our Small Business Development Center will help evaluate each business to make sure they are good candidates for this grant and will help them bring their product idea to market," said Mark Zimmerman, IEDC president.

NRRI has helped many regional businesses over its 30-plus years in Duluth and on the Iron Range. According to Larry Heggedahl, plant manager for Mat, Inc. in Floodwood, MN, partnering with NRRI is "priceless." The company manufactures a line of erosion and revegetation products and has used NRRI's expertise in natural fibers and materials to continue to innovate.

"We've exchanged a lot of in-kind services over the years for their assistance," said Heggedahl. "It's great to work with people who understand how materials work in specific applications."

Lonza, Inc. in Cohasset produces a tree-based ingredient for a variety of products. This small company used NRRI expertise to find appropriate uses for wood waste and to reduce dust in the plant.

Business Assistance Fund Manager Shima Hosseinpour (right) discusses Six Sigma Lean manufacturing processes with Heidi Zierden, a trainer in this methodology.

# Renewable Energy Lab Delivers Results

After 10 years of research, NRRI delivers solid biofuels by the ton.



Right: Researchers in the bioproducts lab, Kendall Carden (left) and Matt Young, continue mixing and testing a variety of biomass feedstocks for renewable energy solid biofuels. A barrel of freshly pressed solid biofuel (below) awaits testing at NRRI's Renewable Energy Lab in Coleraine, Minn.



Starting at the bench scale in 2003 and fiddling with mixture after mixture, NRRI is now able to produce solid biofuels that perform at comparable energy values to coal in fossil coal-burning facilities. The biofuel emissions have no heavy metal pollutants and greatly reduced sulfur levels. As an added benefit, the biomass feedstock can be invasive plants, woody and agricultural waste, secondary wood species, and beetle-killed wood resources.

NRRI envisions this to be a supplement to fossil coal that helps reduce harmful coal emissions to meet state and federal mandates while minimizing new capital requirements at existing power and industrial plants.

“What’s really exciting, and what we’ve been working so hard on, is being able to produce this product at a commercially-relevant scale,” said Don Fosnacht, NRRI director of the Renewable Energy Initiative. “We had to find a way to make it physically robust and water-resistant for easy shipping and handling, and scale it up to 6 tons per day output. It wasn’t easy.”

The United States is moving away from fossil fuels – Oregon is the first

state to aim for coal-free power by 2020 – but the transition will be slow. NRRI helped to monitor a significant trial of solid biofuel at a Portland electric plant in 2017. They completely replaced the fossil coal with 3,500 tons of biofuel with only minor mechanical changes. This trial demonstrated that this similar biofuel provides roughly 2,500 BTU per pound increase over typical output for Powder River Basin coals.

The biofuel can be made with two processes: Torrefaction (a dry roasting method) or Hydrothermal Carbonization (a pressure cooking method). NRRI’s large scale rotary kiln is best for roasting wood chips to make solid fuels. The second reactor is like a large pressure cooker that can take other plant biomass (milfoil, invasive cattails and agricultural waste) to make an “energy mud” that is formed into solid fuels.

“If you think about how Mother Nature made fossil coal, it’s time, pressure and heat,” explained NRRI Engineer Tim Hagen. “We’re doing those same processes, but instead of millions of years, we’re doing it in a few hours. And because minerals don’t get into the mix, we don’t

have those potential pollutants.”

And while this is exciting progress, NRRI is already gearing up for the next steps of biofuel development. Using a high pressure gasification process on the solid fuels, they hope to demonstrate the conversion of the solid biofuel into a synthetic natural gas (sometimes called “syngas”). Other products would be high value chemicals, liquid fuels and activated carbon.

White wood pellets have made it to market as a coal alternative and they’re a large U.S. export to Europe. But unlike NRRI’s solid biofuel, white wood pellets require major infrastructure changes at the power plant including massive warehouses, and they easily break down during transport and exposure to weather.

NRRI’s renewable energy research was funded by a grant from Xcel Energy, Minnesota Next Generation Energy Board/MN Dept. of Agriculture, Minnesota Power, Heetway, K.R.Komarek, Inc. and the Consortium for Advanced Wood to Energy Solutions.

# Funding Infusion Helps Prepare Minnesota for a Changing Economy



New hire Tim White unpacks and settles into his new role as NRRI Business Development Manager, a joint position with the University's Office for Technology Commercialization.

Thanks to support from many corners, state legislators approved in June an annual increase of \$2 million in recurring funds for NRRI, shoring up state support that had remained unchanged from the mid-1980s. While it doesn't keep pace with decades of inflation, this infusion will allow NRRI to grow in areas critical to Minnesota's future.

"This funding will provide added support for our researchers to leverage in pursuing broader grant funding and will allow NRRI to attract top talent and skill sets," said Rolf Weberg, NRRI executive director. "We want to continue to build our team so that we can deliver a meaningful return on investment for Minnesota."

To accomplish this, NRRI is adding and expanding research positions to build the portfolio of tomorrow's economic opportunities.

A business development position will dovetail with the University's Office for Technology Commercialization to clearly identify the state's opportunities so that NRRI can pursue and develop them with the right project partners. This person will also identify intellectual property potential to protect Minnesota's investment in NRRI.

"This position will be key to enhancing Minnesota's ability

to attract industry and reduce industry risk," added Weberg.

NRRI will be seeking a new leader for its chemistry lab to drive higher value materials, chemicals and fuels from natural resources as a foundation for the state's emerging bioeconomy. NRRI has a long history of success with scaling up extraction processes for business development. On the horizon are high value products from wood fiber, mining waste and cranberry byproducts. Weberg is also exploring ways to engage NRRI with other University faculty and experts in materials science.

This position, with multiple collaborations, will enhance UMD's new Chemistry and Materials Science focus by scaling up processes on their way to commercialization.

Weberg has also redefined two more positions that will augment NRRI's unique expertise. A silviculturist will be sought who can span the conversation between production forestry and forest ecology. And a hydro-geologist would help NRRI tie water resources to geology and interactions with the environment.

"We're going for hard-hitting projects. We're going for impact," said Weberg. "The enhanced state funding will bring us people who can make a difference and engage broadly."

# Ilmenite Resources Show Promise for High Value Titanium Dioxide

"I believe we are on the cusp of a new mining industry here in northeastern Minnesota." Bill Ulland, president of American Shield Titanium Group LLC is talking about the new opportunities for a titanium industry for the state - a door opened by NRRI research in 2017.

It's long been known that among Northeastern Minnesota's rich mineral mix are deposits of ilmenite. This is the mineral from which we get titanium dioxide, used in hundreds of daily use products, and eventually for titanium metal. The challenge with commercializing the resource has been the magnesium oxide impurities that couldn't be removed with conventional processing.

NRRI partnered with Process Research Ortech, Inc. (PRO) to demonstrate a proprietary hydrometallurgical process to produce nearly pure titanium dioxide concentrate with high market value. Currently, titanium dioxide's market value is approximately \$3,200 per ton. For comparison, the market value of Iron Range taconite pellets is about \$70 per ton.

NRRI tested a 10-ton sample of rock from a deposit called "Longnose" owned by American Shield Titanium Group LLC. It is the largest and richest ilmenite deposit in the United States. This particular deposit also has low overburden, a confined mining footprint and low sulfur content.

"This process demonstrated by NRRI and PRO appears to be very cost effective with commercial potential," said Ulland. "There's a very strong market now for titanium dioxide."

The separation process recovered an estimated 64 percent of ilmenite as concentrate. The following PRO technology targeted

## the **TIMBERJAY**

MINING

### Major advance for ilmenite mining in region

## MESABI DAILY NEWS

### A new generation of mining

Ilmenite discovery on the Range produces high-quality titanium dioxide

LEAH RYAN  
MESABI DAILY NEWS

Recent metallurgical research by Natural Resources Research Institute (NRRI) and Process Research Ortech (PRO) on an area ilmenite deposit has shown to produce high quality titanium dioxide.

yield a higher purity percentage.

"The findings of this study are important because Minnesota has a significant resource that we hadn't been able to extract valuable products from," explained Matthew Milnar, NRRI research coordinator of Mineral Processing and program



Headlines from newspaper articles about ilmenite research.

removal of iron and titanium oxides. After two scale-up processes, NRRI and PRO were able to achieve titanium purity of 99.8 percent. Pure iron oxides were also separated at 98.5 percent (unoptimized) purity and could add to the market value of the deposit.

"This is especially exciting because we have an opportunity to process the ilmenite to an end product, titanium dioxide, here in Minnesota," said NRRI Executive Director Rolf Weberg. "NRRI's role is to define the state's portfolio of mineral opportunities. That is how we retain wealth, add value to our resources and take care of our environment."

A preliminary marketing study by UMD's Center for Economic Development found that there are few U.S. producers of titanium dioxide and many consumers for

a wide variety of applications - especially in paints and coatings, plastics and paper. With further processing, titanium dioxide can also be used for titanium metal production and niche products, like electronics and energy storage. NRRI intends to seek further funding to pursue additional geological, metallurgical and environmental studies. One goal is to optimize the hydromet process for iron and titanium, and to understand the feasibility of isolating other high value materials.

This project was funded by the Iron Range Resources and Rehabilitation Board, the UMD Vice Chancellor for Academic Affairs and the UMN Office of the Vice President for Research.

# Research Portfolio

Spanning six strategic initiatives, sponsored research and service contracts address important issues for Minnesota's economy and natural resources.

Located at the crossroads of forestry, mining and water, NRRI is uniquely suited to address important issues for Minnesota's economy and natural resources. Our Strategy and Development Advisory Board guides us to balance our research portfolio across basic and applied research with short- and long-term impacts. Some projects span five to ten years, gathering data and creating metrics to gauge impacts on the environment. Some projects are short-term and respond to urgent issues, providing immediate solutions and options to assist businesses, industry and resource decision makers.

Our projects span **six strategic initiatives** (below), with comprehensive application of capabilities and experience from across multiple disciplines.

## Minerals, Metallurgy & Mining

In order to maintain Minnesota's mining economy for the present and into the future, the Minerals, Metallurgy and Mining Initiative works collaboratively with university researchers and industry and government leaders to characterize Minnesota's abundance of ferrous, non-ferrous, aggregate, and mineral by-product resources. The primary mission is to develop efficient, effective, and environmentally viable solutions to scientifically, economically and socially maximize mineral resources.

The Initiative's research directly addresses issues currently facing Minnesota's mineral industry, including the need for higher value mineral products, reduced cost of iron ore recovery, realizing Minnesota's mineral portfolio, and developing new techniques for mineral processing that balance water-ecology-mineral interactions in the environment.

## Renewable Energy

Raw biomass by itself is often difficult to use in conventional applications because of its bulk density, energy content and tendency for biological degradation.

The Renewable Energy Initiative has focused on two pretreatment technologies - torrefaction and hydrothermal carbonization - that overcome these problems and produce a more "user-friendly," improved solid material.

Work by this Initiative will facilitate potential commercialization of these technologies for a variety of partners for both fuel and advanced material applications. The technologies will be developed to the demonstration scale at NRRI's Coleraine facility.

## Wood Products & Bioeconomy

Evolving consumer preferences, and societal demands for more sustainable products, services and lifestyles has put pressure on the forest and bio-based products industries.

To address these challenges, Wood Products and Bioeconomy Initiative scientists and engineers collaborate with public and private stakeholders to transform scientific, technological and engineering advances into opportunities that create value for the people of our region.

For example, projects in the past year have led to formation of a new startup business, developed new chemical products made from biomass, and produced critical performance data for new modified wood products from regional timber.

## Forest & Land

The goal of the Forest and Land Initiative is to deliver research solutions for forests and other terrestrial ecosystems that provide for a sustainable, resource-based economy and a healthy environment.

This Initiative's research ranges from studies of stand-level silvicultural treatments for red pine and aspen forests to landscape-scale assessments that address forest land conversion risk and cross-agency planning.

We address contemporary forest resource issues, including the availability of timber for traditional forest products and the emerging bioeconomy, the ability to create resilient forests in the face of climate change and invasive species, and maintaining healthy and balanced wildlife populations.

## Water

The Water Initiative uses a systems approach to first identify threats to water quality and aquatic resources, identify a range of solutions aimed at preventing and reducing impacts, and restoring these resources.

This Initiative's studies encompass environmental assessment across local to regional scales, and development of tools and technologies for environmental remediation of industrial, municipal, and natural systems.

We address a range of threats and issues ranging from stormwater, invasive species, point and nonpoint source pollution, and climate change.

## Business & Entrepreneurship

The Business and Entrepreneurship Initiative supports regional businesses and job creation through technical assistance. NRRI partners with business owners and entrepreneurs to provide opportunities to grow and expand their businesses.

Within this Initiative, the Business Assistance Fund offers opportunities for businesses to explore new products or processes in manufacturing to increase revenue. NRRI's Rapid Prototype Center provides design and prototype services to businesses, industry, entrepreneurs and university researchers. NRRI also partners with the UMD Center for Economic Development for market research and feasibility analysis.

# Minnesota Mining & Water Innovation



In 2017, the state legislature appropriated \$2.6 million to NRRI with ambitious goals – increase Minnesota’s competitiveness, retain value of our resources and protect water quality. We embarked on five projects to achieve those goals. Here’s our progress report.

## Fixed Bed Dynamic DRI Process Simulator

This tool will help taconite pellet producers transition to higher value iron products. Markets for taconite pellets are dwindling as the need for higher value iron products, like Direct Reduced Grade (DRG) and Direct Reduced Iron (DRI), is increasing due to the rise in electric arc furnaces. This simulator will model Minnesota’s different ore bodies to understand parameters important to production, like metalization, compression strength and fines generated, without doing costly commercial-scale trials.

**Update:** Design of the simulator is being finalized with extensive consultation with industry partners. Construction of the unit will begin in early 2018 with commissioning in the third quarter of 2018.

## Natural Resources Atlas for Northeast Minnesota: A Tool for Decision-makers

Legislators, resource management agencies, industry leaders and citizens need access to vast amounts of vetted data that helps them understand complex issues. NRRI is developing an interactive, online Natural Resource Atlas for Northeast Minnesota that provides location-based information on minerals, forests, water quality, land use, infrastructure and much more. It can also be used to identify areas in need of restoration or enhanced protection. This is a collaborative effort with multiple state agencies to be sure the correct data is gathered and included.

**Update:** Minnesota’s ilmenite deposits and wetlands have been identified as atlas demonstration projects because of immediate development needs. Advisory committees have been formed from academia, state and federal agencies, and private industry. The developers of similar tools were interviewed to identify successes, challenges and recommendations. End-users were also consulted for input and background work on the website and a GIS tool is underway. The initial demonstration site is promising.

## Increasing Iron Recovery from Minnesota Iron Resources

Working with industry partners, NRRI is developing and demonstrating on a pilot-scale, proprietary technology that will harvest magnetic and non-magnetic iron from mined ores. Why? So that Minnesota has a technology base to process all of the ore resources on the Iron Range, including the non-magnetic and more oxidized ores on the west end. This will drive higher yield from currently operating mines.

**Update:** The first shipment of 30 tons of taconite ore samples arrived at NRRI’s lab in mid-October. NRRI researchers will develop models of the composition of ore bodies around Minnesota to test the efficacy of the technology. More R&D collaboration with industry partners is under way to define the impacts on process water, characterize the ore, etc., in applying this technology. The target is to pilot the technology in the second quarter of 2018.

## Microbial Iron Liberation: Methods for Sustainable Sulfate Removal from Mine Waters

NRRI is developing a cost effective and versatile way to release iron from ores while sequestering sulfate for removal from water bodies using naturally-occurring bacteria. The first process – converting the sulfate to sulfide with bacteria – is well known. The second step is the challenge: getting the sulfide to bind to specific metals so it can be removed. This long-term solution for sulfide removal will use Minnesota’s waste taconite resources as a reactive iron. The project is being executed in close collaboration between NRRI, UMD and UM Twin Cities campuses.

**Update:** Completed materials characterization and chemical reactivity of taconite materials. Designed and constructed fixed-bed reactors to couple biological sulfate reduction with iron dissolved by electrolysis. Researchers are developing a way to trap the sulfide permanently.



Don Reiser separates iron ore concentrate using a pilot scale flotation process in NRRI’s Minerals Processing Lab in Coleraine, Minn., as part of the Increasing Iron Recovery from Minnesota Iron Resources project.

## Innovative Water Treatment Technology: Sulfate Reduction Process in Water Systems

Minnesota has unique water quality regulations. Because of northern Minnesota’s native wild rice, the amount of sulfate allowed in water systems has been set much lower than anywhere else in the state: 10 parts per million. And it’s a goal that NRRI is working to achieve with innovative technologies and assistance from an industry partner, Process Research Ortech, Inc. Lab scale testing has shown promise in reducing sulfates at the 100 – 70 ppm to 10 ppm.

**Update:** NRRI will continue to scale up this technology, in combination with other technology platforms, to pilot at the demonstration scale. Researchers are also testing other techniques to reduce sulfates in water bodies with sulfate levels as high as 30,000 ppm.

# Grants, Cooperative Agreements, and Sponsored Projects

 Wood Products & Bioeconomy
  Forest & Land
  Renewable Energy
  Minerals, Metallurgy & Mining
  Water
  Business & Entrepreneurship

**Developing a Decision Support System for Prioritizing Protection & Restoration of Great Lakes Coastal Wetlands**   
 Central Michigan University (US FWS)

**Great Lakes Coastal Wetland Monitoring: Continued Implementation**   
 Central Michigan University (US EPA)

**Functional Indicators of Coastal Wetland Condition**   
 Central Michigan University (USGS)

**Maintenance for the Wetland Restoration Tool**   
 Minnesota Pollution Control Agency

**American Marten Habitat Use**   
 Minnesota Dept. of Natural Resources

**Research and Development of Ballast Water Treatment Systems**   
 Northeast-Midwest Institute

**Evaluation and Verification of Ballast Water Treatment Technologies**   
 University of Wisconsin-Superior (US DOT)

**Biomass Briquettes for Coal Replacement**   
 USDA Forest Service

**Poplar Genetic Improvement and Preservation**   
 Battelle Energy Alliance, LLC (US DOE)

**SunGrant Initiative Hybrid Poplar Development Plan**   
 South Dakota State University (US DOE)

**St. Louis River Area of Concern Data Visualization**   
 Minnesota's Lake Superior Coastal Program

**Paleolimnology of the St. Louis River Estuary in Support of Delisting the Area of Concern**   
 Minnesota Pollution Control Agency

**Comparing Properties of Water Absorbing/Filtering Media for Bioslope/Bioswale Design**   
 Minnesota Dept. of Transportation

**Adaptive Management of Untreated Urban Runoff**   
 USDI US Geological Survey

**Endangered Bats, White-Nose Syndrome, and Forest Habitat**   
 Minnesota Dept. of Natural Resources

**Little Brown Bat Telemetry at Lake Vermilion-Soudan Underground Mine State Park**   
 Minnesota Dept. of Natural Resources

**Summer Habitat Use by Bats in Managed Minnesota Forests**   
 National Council for Air and Stream Improvement

**Munger Wetlands Invertebrate and Aquatic Vegetation Sampling**   
 USDI Fish and Wildlife Service

**Climate Change Adaptation Planning for Northern Forest Ecosystems in the Great Lakes National Parks**   
 USDI Cooperative Ecosystem Studies Unit

**Duluth Streams Urban Watershed Restoration and Protection**   
 Minnesota Pollution Control Agency

**Duluth Area Watersheds Protection Framework**   
 Minnesota Dept. of Natural Resources

**Wood Turtle Telemetry**   
 Minnesota Dept. of Natural Resources

**Chemical Modification of Peat Granules Surface for Wastewater Treatment**   
 American Peat Technology, LLC

**Climatic and Anthropogenic Forcing of Wetland Landscape Connectivity in the Great Plains**   
 National Science Foundation

**Minnesota Forest Productivity Research Cooperative**   
 Minnesota Dept. of Natural Resources, Minnesota Power, Molpus Timberland, LLC

**Conducting a Condition Assessment of Nearshore Fish Habitats in the Great Lakes Basin**   
 University of Michigan (Great Lakes Fisheries Trust)

**Improving Brook Trout Stream Habitat Through Beaver Management**   
 University of Bemidji (Minnesota ENRTF\*)

**Prioritizing Future Management of North Shore Trout Streams**   
 Minnesota ENRTF\*

**North Shore Superior and Northeastern Minn. Lake and Stream Water Assessment**   
 Minnesota Pollution Control Agency

**Demonstrating Potential for Distributed Power Generation Using Converted Biomass**   
 Xcel Energy

**Using Thermal Modification Technology to Add Value to Small-Diameter Logs from Underutilized Species**   
 USDA Forest Service

**Assessing Forest Land Conversion Risk to Maintain Water Quality in North Central Minnesota**   
 Minnesota Dept. of Natural Resources

**Wolf-Moose Interactions in North Eastern Minnesota**   
 Minnesota Zoo

**Genetic and Camera Techniques to Estimate Carnivore Populations**   
 Minnesota ENRTF\*

**Emerald Ash Borer and Black Ash Wildlife Impacts**   
 Minnesota ENRTF\*

**St. Louis County Aquatic Invasive Species Introduction Risk Assessment**   
 St. Louis County

**Baseline Surveys and Geospatial Modeling of Aquatic Invasive Species**   
 St. Louis County

**What Gear on Your Boat is Most Likely to Spread Spiny Water Flea?**   
 St. Louis County

**Determining Highest Risk Vectors of Spiny Water Flea**   
 Minnesota Aquatic Invasive Species Research Center (Minnesota ENRTF\*)

**Metagenomic Approaches to Develop Biological Control Strategies for Aquatic Invasive Species**   
 Minnesota Aquatic Invasive Species Research Center (Minnesota ENRTF\*)

\*Environmental and Natural Resources Trust Fund

Assessing Acid Sensitive Lakes in Northern Minnesota 🌊  
USDI Cooperative  
Ecosystem Studies Unit

Development and Integration of Advanced Timber Bridge Inspection Techniques for National Bridge Inspection Standards 🏗️  
Minnesota Dept. of Transportation

Using Statewide LiDAR to Quantify the Distribution and Productivity of Minnesota Red Pine and Aspen Forests 🌲  
Blandin Foundation

Tidal Marsh Elevation Response to Long-term Fertilization and Impacts for Resilience to Sea-Level Rise 🌊  
USDI Cooperative  
Ecosystem Studies Unit

Minnesota Breeding Bird Atlas 🌲  
Minnesota Audubon  
(Minnesota ENRTF\*)

Post-Burn Bird Surveys at Pagami River, Superior National Forest 🌲  
Northern Research Station

Connecticut Warbler Habitat Management Survey 🌲  
Minnesota Dept. of Natural Resources

Monitoring Breeding Bird Populations in Chippewa and Superior National Forests 🌲  
USDA Forest Service

Conservation of Common Terns in Lake Superior 🌲  
Minnesota's Lake Superior Coastal Program

Enhanced Microbial Sulfate Removal and Recovery through a Novel Electrode-Integrated Bioreactor 🌊  
USDI US Geological Survey

Optimized Taconite-Based Pavement Repair Compound and Deployment System 🏗️  
Minnesota Dept. of Transportation

Vertical Phytoplankton Community Structure and Primary Productivity in Western Lake Superior 🌊  
UMD Sea Grant Omnibus  
(National Oceanic and Atmospheric Administration)

Mortality of Fathead Minnow Larvae and Juveniles through Two Common Livewell Pumps 🌊  
UMD Sea Grant Omnibus  
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Integrative Social and Hydrobiologic Models for Enhanced Resiliency of Coastal Communities under Extreme Weather Events 🌊  
UMD Sea Grant Omnibus  
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Paleolimnology of the St. Louis River Estuary 🌊  
UMD Sea Grant Omnibus  
(National Oceanic and Atmospheric Administration)

Great Lakes Biological Monitoring: Phytoplankton 🌊  
US Environmental Protection Agency

Consortium for Advanced Wood-to-Energy Solutions ⚡  
US Endowment for Forestry and Communities, Inc

Dredged Sediment for Forest Restoration on Minelands 🌲 🏗️  
Minnesota ENRTF\*

Regional Biomass Feedstock Partnership: Poplar 🌲  
South Dakota State University (US DOE)

Event Based Stream Sampling in Northeastern Minnesota 🌊  
Minnesota Pollution Control Agency

Improving Log Defect Detection by Combining Complementary Scanning Methods 🏗️  
USDA Forest Products Laboratory

Assessment of Natural Copper-Nickel Bedrocks on Water Quality 🌊 🏗️  
Minnesota ENRTF\*

Eagles Nest Geotechnical Survey 🏗️  
Minnesota Dept. of Transportation

Cost-competitive Timber Bridge Designs for Long-Term Performance 🏗️  
Minnesota Dept. of Transportation

Operational Thinning Trials in Red Pine Stands 🌲  
Potlatch Corporation

MN State Wood Innovation Team 🌲 ⚡  
USDA Forest Service

Liquid Fuels Production via High-Pressure Gasification ⚡  
Minnesota Dept. of Agriculture

Lake Superior Beach Monitoring and Advisory Program 🌊  
Minnesota Dept. of Health

Northeast Minnesota White Cedar Restoration 🌲  
Minnesota Board of Water and Soil Resources

Evaluation of Tree Retention Guidelines Pertaining to Wildlife 🌲  
Minnesota ENRTF\*

Building Deconstruction to Reduce Greenhouse Gas Emissions and Solid Waste 🏗️ ⚡ 🌲  
Minnesota ENRTF\*

Minnesota Mining Cluster - The Next Generation of Innovation Product Development Support 🏗️ ⚡ 🌲 🌊  
US Dept. of Commerce

Pilot Scale Demonstration of Ilmenite Processing Technology 🏗️ ⚡  
Dept. of Iron Range Resources and Rehabilitation, UMN Office of the Vice President for Research, and UMD Executive Vice Chancellor for Academic Affairs

## Service Contracts and External Sales

🏗️ Wood Products & Bioeconomy   🌲 Forest & Land   ⚡ Renewable Energy   🏗️ Minerals, Metallurgy & Mining   🌊 Water   👤 Business & Entrepreneurship

More than 80 private businesses, companies, associations, universities, and research science centers engaged NRRI for service contracts in FY17. These groups and individuals partner with NRRI to utilize our unique capabilities and experience. We assist with basic and applied research activities, and also provide consulting, analytical testing, prototyping, and product development and testing. In 2016 we began providing Six Sigma/LEAN tools and have assisted businesses in streamlining their processes and maximizing efficient use of their financial and personnel resources.

## Where are they now?

Two former NRRI student workers enter the workforce and continue their education



Former NRRI student worker Amanda McGraw holds a fawn, eyes covered to minimize trauma, as part of a capture and collaring project for the Wisconsin Department of Natural Resources. Today, McGraw is a Research Scientist for the Wisconsin DNR and a Ph.D. candidate. (Photo courtesy of A. McGraw)

### Amanda McGraw

Research Scientist & Ph.D. Student

After slogging through swamps and pulling more ticks off herself than she could count, Amanda McGraw decided as an undergraduate freshman that a career in natural resource science was for her.

McGraw received a Bachelor of Science degree in 2008 in Wildlife Ecology from UW Madison, then continued in that field at UMD for her Master's degree, completing that in 2010. And her work as a graduate student on NRRI's moose research team, under the leadership of Principal Investigator Ron Moen, has led to her dream job with the Wisconsin Department of Natural Resources.

"From start to finish, everything I learned during my time at NRRI - from trapping and collaring to logistics and preparation - has helped me tremendously in my current role," said McGraw. "Those projects also taught me the importance of collaboration and teamwork."

Field work for the moose researchers is often done in harsh conditions - winter's bitter cold or hot and buggy conditions of summer - so McGraw learned that comradery among team members goes a long way. She also leans on the network of natural resources professionals she built through her NRRI work.

She is now a Research Scientist developing a state-wide project to understand the linkages between deer health and habitat quality and is enjoying working with an engaged and creative work team. At the same time she's working on her Ph.D. dissertation focused on habitat use by moose and deer in northeast Minnesota. McGraw expects to achieve her UMN doctorate degree in early 2018.

NRRI supports the University of Minnesota's goals of providing quality, hands-on training to students by involving students in research and mentoring them in their professional development. NRRI offers unique employment and experiential learning opportunities to employees and students that in many cases result in successful job searches and career transitions. In turn, NRRI is enriched by the contributions of our temporary employees, some of whom remain to join the NRRI team. Numbers are for the 2017 fiscal year.

**26 Undergraduate and 15 Graduate Students Trained**

**30 Short-Term Research Employees Trained**



Former NRRI student worker Richie Vang conducts a lab experiment with zinc electroplating solutions at Federal Mogul Powertrain in Detroit, Mich. Vang is a Quality Systems Engineer in their Ignition Group. (Photo courtesy of R. Vang)

## Richie Vang

### Quality Systems Engineer

Richie Vang had a lot of fun getting to where he is today. As a Quality Systems Engineer with Federal Mogul Powertrain in Detroit, Mich., he is leading a global project to implement a quality system for their Ignition Group.

What helped him get the job was the variety of experiences he had as a NRRI student worker completing a Bachelor's degree in Chemical Engineering at UMD. From riding ATVs and snowmobiles to track moose and wolves on Ron Moen's research team, to leading projects in the Machine Shop under the tutelage of Manager Steve Johnson; the fun taught him a lot.

"My first job at NRRI as a wildlife student researcher gave me skills and experience in research, experimentation and data analysis," said Vang. "My second NRRI job gave me machining skills and project management experience."

His experiences at NRRI are translating well to his career. He understands that, as an engineer, good communication and management skills go hand-in-hand with mechanical skills. The diversity of expertise at NRRI allowed him to work alongside Ph.D. researchers, graduate students, scientists in many fields and universities, and local business owners.

"In the Machine Shop, I met with customers to understand their concept then, with supervision, I did everything from the initial design, ordered materials and then made it a reality," Vang said. "I got exposed to a little bit of everything which was great for building my resume."

# Accomplishments and Recognition

## JERRY NIEMI RECEIVES THOMAS S. ROBERTS MEMORIAL AWARD

Sometimes receiving an award is especially meaningful. That was the case for NRRI Scientist Jerry Niemi when he received the Thomas S. Roberts Memorial Award in December 2016. His project, the Minnesota Breeding Bird Atlas, dovetails with previous documentation of the state's bird species by Roberts published in 1932. The award was bestowed by the Minnesota Ornithologists Union for Niemi's "outstanding contributions to Minnesota Ornithology and birding."

The Atlas establishes the status of Minnesota's breeding bird population from 2009 to 2013. Roberts' work in the late 1800s and early 1900s provides the only basis for a historical comparison of changes on Minnesota's birds over the past 100 - 150 years.

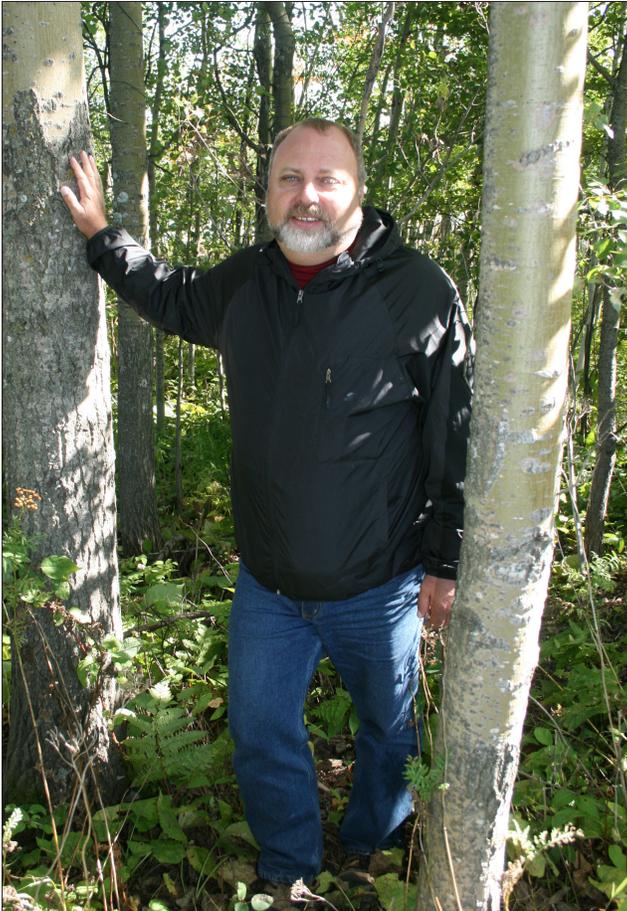
Niemi served 20 years as director of NRRI's Center for Water and the Environment before returning to research and teaching biology at UMD. Themes of his research have included forest and wetland birds, raptor biology, indicators of healthy ecosystems and sustainable natural resource management.

Niemi was nominated for the award by MOU members Janet Green and Lee Pfannmuller. "Among a very diverse group of stakeholders, who often have very polarized views about forest management, Jerry is widely recognized as a calm, non-biased voice that all hold in high respect," said Pfannmuller.



Senior Researcher and Professor Jerry Niemi holds the Thomas S. Roberts Memorial Award he received in December 2016.

## BILL BERGUSON: GROWING HIS CAREER AT NRRI



Silviculturist Bill Berguson stands among fast-growing hybrid poplars growing near NRRI's Duluth Labs.

Silviculturist Bill Berguson joined the NRRI team in 1986 to build a forestry program that would give the state's vital forest products industry a needed shot in the arm. Thirty years later he celebrated his retirement in early 2017. During those decades, Berguson grew what is now one of the largest and most comprehensive hybrid poplar genetics and breeding programs in the world.

Building on USDA Forest Service research initiated in the 1970s, these fast-growing trees are capable of reaching harvest size in 10 to 12 years, and were incorporated into a local paper mill's feedstock. Hybrid poplars are also recognized as a dedicated resource for Minnesota's nascent bioenergy and bioproducts industry.

Still, aspen and red pine are essential species for Minnesota's forest industry. Berguson led a team effort on pre-commercial thinning of aspen that was adopted by industry, increasing productivity and supply for area mills. Red pine analysis helped expand the largest sawmill in Minnesota, and research on stand thinning was incorporated into the Department of Natural Resources Red Pine Manager's Handbook.

Berguson co-founded the Minnesota Hybrid Poplar Research Cooperative in 1996, and founded the Minnesota Forest Productivity Cooperative in 2004. He helped develop guidelines for use of biomass from forests and brushlands through an appointment to the Minnesota Forest Resources Council, and served as the Poplar Species National Team Leader for the Department of Energy from 2010-2017.

Among his many national contributions, Berguson provided important information to the Department of Energy in estimating U.S. biomass production capabilities for its important Billion Ton Study and subsequent updates.

NRRI has two advisory boards that represent a blend of stakeholders and community leaders. The advisory boards have different functions and together they work to inform, guide, and advise NRRI leadership in pursuing mission-focused initiatives.

The Community Impact group interfaces directly with the public to bring the voices of customers and stakeholders to NRRI leadership and the strategy and development board. Their role is to maintain relationships and connections to the community and groups we serve.

The Strategy and Development group gives perspective and guides NRRI in executing the mission and achieving the institute's overarching goals, and developing a balanced funding portfolio. They incorporate voices from the community and stakeholders to provide ongoing input into NRRI's focus and mission.

The membership of advisory boards continues to evolve alongside the institute.

## COMMUNITY IMPACT ADVISORY BOARD (2016/2017)

The Community Impact Advisory Board is composed of individuals with extensive experience with specific stakeholder groups representing the spectrum of NRRI's **six research areas**:

 Wood Products & Bioeconomy
  Forest & Land
  Renewable Energy
  Minerals, Metallurgy & Mining
  Water
  Business & Entrepreneurship

**Julie Marinucci**   
Senior Project Engineer, Short Elliott Hendrickson Inc.

**Kate Ferguson**   
Director of Business Development, Duluth Seaway Port Authority

**John Downing**   
Director, UMD Minnesota Sea Grant

**Brendan Jordan**   
Vice President, Great Plains Institute

**Randy Kolka**   
Team Leader and Research Soil Scientist, USDA Forest Service

**Jack LaVoy**   
Executive Director, Great Lakes Aquarium

**Vince Magnuson**   
Retired UMD Vice Chancellor, Chemistry/Biochemistry

**Joe Mayasich**   
Director of Environmental Services, Western Lake Superior Sanitary District

**Frank Ongaro**   
Executive Director, Mining Minnesota

**Brian Palik**   
Team Leader and Research Ecologist, USDA Forest Service

**Ida Rukavina**   
Northern Minnesota Citizen

**Peter Sellwood**   
Financial Advisor, Morgan Stanley

## STRATEGY & DEVELOPMENT ADVISORY BOARD (2016/2017)

The Strategy and Development Advisory Board is composed of individuals with experience that reflects the three cornerstones of the mission: economy, environment and resources, and resilient communities.

**Mike Mlinar**  
Retired Vice President, Cliffs Natural Resources, Inc.  
Senior Consultant Mining and Resource Services, Krech Ojard Associates

**Al Rudeck**  
President, Allele Clean Energy

**Sue Galatowitsch**  
Professor and Head of UMN Dept. of Fisheries, Wildlife, and Conservation Biology

**Mark Phillips**  
Commissioner, Iron Range Resources and Rehabilitation Board

**Yvonne Prettner Solon**  
Consultant on energy policy, Former MN Lt. Governor, MN Senator

**Andrea Schokker**  
Professor and Head of UMD Civil Engineering

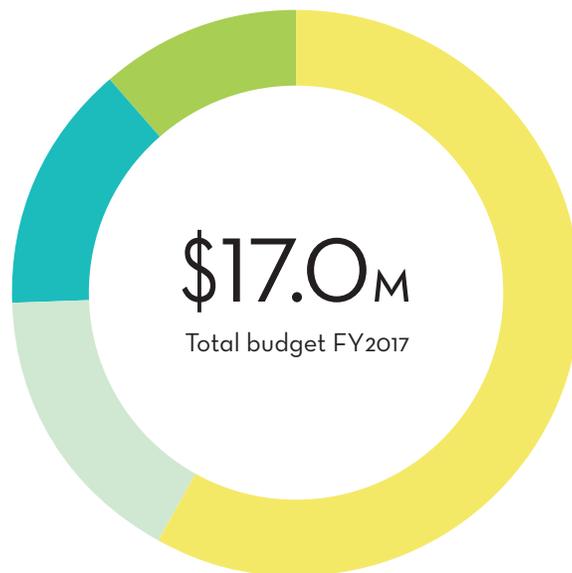
**Jay Schrankler**  
Executive Director, UMN Office for Technology Commercialization

**Tony Sertich**  
President, Northland Foundation

**Deb Swackhamer**  
Retired Professor; Director of UMN Water Resources Center

## OPERATING BUDGET FOR FY 2017

- **Contracts and Competitive Grants • 58.2%**  
 Federal, state and local grants, service agreements and contracts generated primarily by application of base funding.
- **Coleraine Lab Support • 16.5%**  
 Permanent University Trust Fund dedicated to Coleraine mining research and site support  
*Primary applications are project support, matching funds, salaries and benefits, facility repair and upgrade, site operations, grant preparation, and equipment.*
- **State Base Funding • 14.1%**  
 State-mandated funding to provide research support  
*Primary applications include matching funds, salaries and benefits, utilities, grant preparation, equipment, safety, and conferences, training, and travel.*
- **University Funding • 11.2%**  
 Operations and Maintenance  
*Current applications include matching funds, salaries and benefits, facilities repair and upgrade, grant preparation, and equipment.*

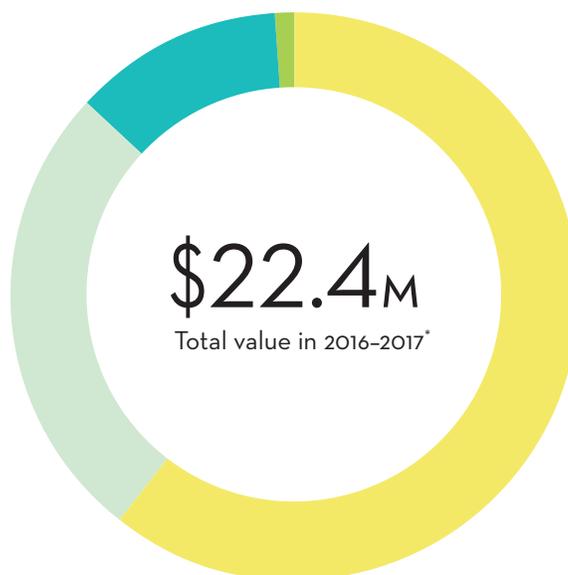


## EXTERNAL FUNDING YEAR-TO-DATE AWARD SOURCES

- **Federal • 60.8%**

Environmental Protection Agency	56.7 %
US Department of Energy	9.8 %
Other Federal	8.6 %
US Department of Agriculture	8.5 %
US Department of Commerce	7.1 %
US Department of the Interior	6.2 %
National Science Foundation	3.1 %
- **State • 26.2%**

Environmental and Natural Resources Trust Fund	42.1 %
Minnesota Department of Natural Resources	21.7 %
Minnesota Department of Transportation	18.1 %
Other State	13.0 %
Minnesota Pollution Control Agency	5.2 %
- **Industry • 12.0%**
- **Other • 1.0%**



\*The total value for grants and contracts uses **all years** of funding for multi-year projects. The total value represents the cumulative value of externally-funded research active between July 2016 and June 2017.

# Keep your eyes on us!

## Here's what we have coming in the 2017-2018 fiscal year:

Expanding the reach of NRRI's Business Assistance Fund to help entrepreneurs and small businesses thrive

NRRI researchers will study Minnesota's potential manganese resources, along with processing innovations and environmental impacts. Manganese is essential to iron and steel production.

New materials development from biomass feedstocks

Continued development in solid biofuels, while moving toward developing a bio-based syngas for higher value fuels and chemicals

Leveraging our state support to continue onboarding new talent, new skills and equipment to deliver research solutions for Minnesota

Addressing the water quality issues with tools specific to Minnesota's environmental challenges.

Additional patents for peat-based water filters to target specific pollutants and an interactive web-based map for invasive species risk assessments.

This report was published by UMD-NRRI in November 2017 and reflects activities between July 1, 2016 and June 30, 2017. This publication is available in alternative formats upon request. Direct requests to the Public Relations Department, [jbrenema@d.umn.edu](mailto:jbrenema@d.umn.edu), (218) 788-2600.

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**Cover:** Clockwise from top: Avian researcher Annie Bracey searches for birds in the St. Louis River estuary as part of NRRI's bird monitoring program, Researcher Matt Young tests two-by-four strength in NRRI's Mechanical Test Lab, unknown NRRI technician pours melted taconite rocks into a form for testing purposes, Research Fellow Elaine Ruzyccki at work in NRRI's Analytical Lab, and Nick Pierce and Kari Hansen record stream temperatures in a rural Duluth stream.

**Back Cover:** NRRI's Fens Research Facility near Zim, Minn., shows off its summer splendor. This 525 acre site was restored by NRRI from drained farmland to a functioning peatland, generating wetland mitigation credits for sale and use in Northeast Minnesota. (Photo credit: Brett Groehler, UMD photographer)

The University of Minnesota, founded in the belief that all people are enriched by understanding, is dedicated to the advancement of learning and the search for truth; to the sharing of this knowledge through education for a diverse community; and to the application of this knowledge to benefit the people of the state, the nation and the world. The University's threefold mission of research and discovery, teaching and learning, and outreach and public service is carried out on multiple campuses and throughout the state.

## We'd like to thank our many sponsors and collaborators:

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Thank you!

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