Final Reports as of August 2006 - #03 Projects

#03-06 Increasing Yield and Management Options for Producers who Traditionally Plant Barley Acres for Grain or Forage Production

Darrin Boss, MSU, Bozeman
Year 1 - $27,375; Year 2 - $19,951
Final report approved August 2006

Summary:
The traditional planting practice combined with the traditional seeding rates may be the worst combination to harvest barley as forage. Forage quality may be altered by manipulating management options associated with seed placement and populations using air drill technology and high populations with wide banding patterns. Grain quality and quantity were not affected by banding in narrow or wide configurations or by varying the population rate. The original hypothesis proposed that banding the seed and increasing populations may benefit by more efficient use of space, light and nutrients. This proved not to be the case, and in contrast, feed grain barley production was actually greatest at lower population rates and narrow band widths. Instead of attempting to manage the barley crop while it is growing, it appears identifying the endpoint and using best management practices for that endpoint is ultimately the best option.

Commercialization Plan:
Results of the trial have been published and presented to county extension agents, machinery sales representatives and producers in Montana. Decreasing nitrate-N levels in barley used for annual forages, using air-drill technology, and planting in wide banding patterns should be beneficial to those producers using barley as annual forage for livestock. Identifying the worst case scenario (which is the current practice employed by many Montana producers) at traditional planting populations with narrow banding patterns, may help solidify the idea that producers may better off to identify specific production goals associated with an endpoint rather than managing the crop through the growing season. Large portions of all annual forages currently have elevated levels of nitrate-N and this study may assist producers in better management, thereby increasing production and profitability

#03-08 Spatial Spectral Coherent Holographic Integrating Processor – S^2-CHIP: Device characterization, performance evaluation and optimization

Wm. Randall Babbitt, MSU, Bozeman
$149,420
Final report approved January 2005

Summary:
The S^2 CHIP device is an optical crystal based device that vastly enhances the performance of broadband signal processing in conventional radar, laser radar, radio astronomy, and other potential applications. The S^2 CHIP was first conceived at Spectrum Lab under a grant funded by NASA. MBRCT funding was critical to moving the technology from the initial demonstration stage to a path of commercialization and production as well as bridging the gap between the

initial matching funds from the ending NASA grant and the beginning of the current Army SMDC contract. The MBRCT and matching funds were used for characterization and performance evaluation of the S2CHIP, development of key enabling technologies, and for securing the intellectual property rights. All the objectives of the MBRCT grant proposal were met. MBRCT support led directly to the current Army SMDC contract awarded to Scientific Materials. The plan under contract is to move the S^2 CHIP technology from the demonstration stage to prototype to a commercial product. The Spectrum Lab is collaborating with Scientific Materials on the Army SMDC contract as well as on two SBIR awards that have resulted from the work.

Commercialization Plan:
Commercialization is under way, although full production will not occur until after 2008.
Product description:
The S^2 CHIP is an optical crystal based device that vastly enhances the performance of broadband signal processing in conventional radar, laser radar, radio astronomy, and other potential applications.
Target market:
The target market is currently the military.

Economic Impacts:
The MBRCT grant was critical in furthering development of the S^2 CHIP and related technologies having led directly to the Army SMDC contract to Scientific Materials, Bozeman, and to a sub-contract to Spectrum Lab from Scientific Materials.

- This is a 5-year effort to produce a prototype for test-bedding after three years and a commercial model after five years. Currently $7.5 million has been authorized for the first three years of a $15.9 million five-year contract.
- MBRCT grant helped Scientific Materials obtain a $100K SBIR with a sub-contract to MSU.
- Scientific Materials has submitted, by invitation, a $750K Phase II SBIR on this project.
- Related technology on laser stabilization developed under NSF PFI and AFOSR grants have been further helped with a $100K SBIR award. The stabilized laser technology is critical to the S2CHIP project with applications in lidar and atomic clocks.
- Scientific Materials has submitted, by invitation, a $750K Phase II SBIR on the above project.
- Spectrum Lab is working with AdvR of Bozeman on the development of waveguide cavity diode lasers to replace the external cavity diode lasers currently used in laser stabilization systems. If the waveguide lasers meet performance specifications for incorporation into S2CHIP products, AdvR will have a new market for its lasers.
- For directly related technology, Spectrum Lab was awarded a $135K sub-contract from NRO (through collaborators at the University of Colorado) to explore lidar processing application of S2CHIP.
- The success of the S2CHIP technology has caused a surge of interest in a related technology: Unity Probability of Intercept Microwave Spectral Analysis and the DARPA grant has been redirected in this direction. If

funded a Phase III project, would be a subcontract from Northrop Grumman for approximately $1 million.

- **New businesses created or expanded**

The S2CHIP program of Scientific Materials and Spectrum Lab moved into a new 10,000 square foot facility just south of the MSU campus.

- **Increase in employment levels**
  - Five new people have been hired by Scientific Materials in the past year and hiring of five more people in the next six months is expected.
  - Hiring of two new staff members into Spectrum Lab in the past year
  - Research funding for several new students and affiliated faculty

- **Patents applied for or granted**

The MBRCT project has contributed to patent protection for the S^2 CHIP and three enabling technologies developed under MBRCT funds.

- **Development of intellectual property**

MSU's S^2 CHIP technology portfolio has been licensed to Scientific Materials Corporation, which in collaboration with Spectrum Lab and others is moving the S^2 CHIP technology from the demonstration stage to a commercial product. The three steps involved in commercialization include rigorous end-to-end device modeling with construction of a sophisticated laboratory test system; specification, design and construction of a prototype device; and, construction of a customer specific first generation production model of the S^2 CHIP device in 2008.

- **Unique features/success stories/news clippings, brochures/other information**
  - The S^2 CHIP technology was written up in the September 12, 2003, issue of the Bozeman Chronicle and was the cover story in the August 22, 2004 issue as one of 12 technologies highlighted in the 2004 MDA Technology Applications Program Calendar.
  - Work presented by Kris Merkel at the GOMACTech-03 conference on the S2CHIP received the George Abraham Outstanding Paper Award presented at GOMACTech-04.

#03-11 Development of Synthetic Seeds for the Mint and Potato Industries of Montana
Duane Johnson – MSU
Year 1 - $65,800; Year 2 - $34,660 award withdrawn by Board
Final Report for year 1 accepted October 2005

Summary:
Purpose: The intent of this project was to utilize tissue culture protocols to rapidly generate germinating artificial seeds of mint and potatoes. The following objectives were identified to meet these goals:

Research Conducted:
Objective 1. Develop a technology to efficiently produce synthetic seeds in mint.
Synthetic seeds were attempted using standard protocols for generating mint embryos from callus tissue derived from stems, leaves and roots. After 8 weeks, the plantlets generated were small and failed to grow in soil media. The project was re-evaluated and it was determined that cost to grow embryos to a size sufficient for field planting would be prohibitive and technically difficult. The project was then revised and synthetic seeds were successfully grown in soil media, transferred to an agar medium and mass encapsulated in a gel cap.

Objective 2. Develop a technology to efficiently produce synthetic seeds in potatoes.
Synthetic seeds were attempted using standard protocols to generate potato embryos from callus tissue derived from stems, leaves and roots. After 10 weeks, the callus failed to generate shoots and roots in artificial media. Modifications were made but regeneration of viable potatoes was unsuccessful.

Objective 3. To field test the resulting "syn seeds" in field trials.
Field testing of the synthetic seeds was conducted at Northwest Agricultural Research Center in Kalispell. Syn seeds from peppermint have shown a 25-40% success rate, which is insufficient to encourage commercial production. Potato production using this system was unsuccessful

Commercial Potential of Research Results:
Syn seed production can be refined and be economically viable for the mint industry. It is not currently viable for potato production.

Patent Application:
The patent application filed in 2003 was rejected by the U.S. Patent Office because the technology was too similar to pre-existing technologies.

#03-13 Development of an Oxygen-Consuming Biological Barrier to Prevent Oxidation of Pyritic Mine Tailings
A.B. Cunningham – Center for Biofilm Engineering – MSU - Bozeman
Year 1 - $64,924; Year 2 - $64,924
Final report approved: January 2005

Summary:
In collaboration with the Center for Biofilm Engineering at MSU, Golden Sunlight Mine and MSE Technology Applications, this project has successfully developed biofilm barrier technology that will prevent the oxidation of pyrite minerals and subsequent generation of Acid Rock Drainage originating from mine waste. The experimental work plan investigated the use of

three organic carbon sources (molasses, cheese whey and methanol) to control acid mine drainage from two tailings sources. A pilot-scale demonstration of the technology was set up using field test plots at Golden Sunlight Mine. This pilot scale test will provide technical and economic data to determine if a full-scale treatment (240 acres) would be a feasible approach for mitigating tailings oxidation for the entire mine site. MSE will serve as the primary contractor for delivering subsurface biofilm barrier technology to the mining industry, thus the results of this project will add significant value to the company by enhancing its' ability to market the technology.

Commercialization Plan:

Product Description:

The product consists of providing biological (oxygen-consuming) barrier technology for the containment and treatment of Acid Rock Drainage resulting from mining activities, to MSE-TA/Center for Innovation customers.

Target Market:

There are more than 60 sites on the EPA's National Priorities list representing total estimated remediation costs ranging between $4 and $45 billion. A typical biological barrier job, such as the one proposed to Golden Sunlight Mine, is expected to have overall revenues of about $1 million. It is estimated there are at least 10,000 mine waste sites in the United States, some of which would benefit from use of the technology. That MSE would have at least one project per year is realistic. The target market is the mining industry and government agencies responsible for mine land reclamation.

Marketing Strategy:

MSE/CFI will market mining operations in Montana and worldwide. Communication with mining representatives from South Africa and Australia indicates the technology will be aggressively considered in those countries. Attendance at trade shows, obtaining lists of potential clients, and presentations at environmental conferences are planned marketing strategies.

Business Risk Assessment:

Technical risks – plugging bacteria being used as a food source by other microorganisms; stimulation of pathogenic bacteria by the nutrient injection; subsurface conditions not conducive to barrier formation.

Acceptance risks – corporations wary of new technologies

Regulatory risks – regulatory agencies may not allow subsurface injection of microorganisms

Economic Impacts:

New Businesses Created or Expanded:

Formation of a new company, the Center for Innovation (CFI), headquartered in Butte. Created in March 2004, CFI is a spin-off company from MSE_TA focused on developing technologies and services in the area of environmental biotechnology. It has acquired contracts for mine waste reclamation projects with Golden Sunlight Mine (Cardwell, MT) and the EPA Mine Waste Program (including developing remediation plans for three orphan sites in the western U.S.).

Increase in Employment Levels:

Ten employees – scientists, engineers and technical and support staff

Other:

MSE_TA/CFI will retain exclusive license to the technology and become a full service provider.

Abstract of thesis by Paul John Sturman is partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil Engineering, entitled "Control of Acid Rock Drainage from Mine Tailings through the Addition of Dissolved Organic Carbon".

#03-15 Montana's NSF-EPSCoR Infrastructure Grant: "Cross Sectional Partnership Building for the Future"
Mark Young – MSU/UM
Year 1 - $1,505,429
Final report approved: January 2005

Summary:
This represents the third year of a successful partnership between NSF and the State of Montana. The governing strategy of the grant was to identify and enhance the science and technology capacity and directly stimulate Montana's economic development. The overall goals included:

1) Development of three target areas to serve as a science and technology foundation to economic development (Integrative Analysis of Complex Biological Systems, Nanotechnology, and Biomolecular Structure and Function)
2) Provide a highly skilled science and technology workforce involved in each of the three target areas
3) Establish new initiatives in education outreach that had a significant regional and national impact
4) In the long term, expand the science and technology capacity of MSU and UM to the entire state of Montana

Expenditure of grant funds through the third year has gone toward:

- Start-up packages and review assistance of SBIR Phase 0, 1.5 and Partnership Development programs
- Aiding Montana small businesses in obtaining federal grant money to develop innovation in Montana
- State Competitive Grants that have fostered new areas of research and growth
- Opportunities for graduates and undergraduates in one-on-one mentoring research and education experiences
- Native American and tribal college programs supporting collaborations with the universities and assisting tribal faculty in program development
- New faculty hire programs to recruit nationally competitive researchers and faculty members
- Technical support for the campus services utilized by campus personnel and private sector business
- Invited Speakers and Visiting Scholar/Faculty development funding to bring in external expertise to present seminars at Montana institutions and communities

Commercialization Plan:
Product description: Lays a foundation of excellence in research and technology and builds on this foundation to define a niche market for Montana companies and graduates.

Target market including size: Target areas for investment, which will lead to an increased research and economic base for Montana, are: Integrative Analysis of Complex Biological Systems, Nanotechnology, and Biomolecular Structure and Function

Economic Impacts:

- Instrumental in developing hardier strains of crops and paved the way for an up-and-coming biotechnology effort in the state.
- Significant increase in clean technology industries
- A college of agriculture major in the now "hot" biotechnology area
- Collaborations with numerous companies around the state
- Seed funding for over 35 Montana based companies to assist in developing proposals for large federal and private funding grants
- Broader education and research opportunities for undergraduates
- Overall increased quality of life for Montana residents

New businesses created or expanded: Instrumental in helping fund researchers who, through innovative discoveries, have collaborated with, and helped to "home grow" about nine laser optics companies in Montana.

Increase in employment levels: Development of high paying jobs for Montana's college graduates in Montana companies

Sales generated:
- Increase in multi-investigator awards – 14 multi-investigator research grants
- Extramural funding exceeding $130 million for UM and MSU campuses

#03-19 Determination of Nerve Depth Through 3D Mathematical Modeling
Philip Cory – Nervonix, Inc. - Bozeman
Year 1 - $79,005; Year 2 - $77,345
Final report approved: January 2005

Summary:
This project was designed to advance technology for the detection and imaging of nerves from the skin surface through application of very low intensity electrical fields by developing a mathematical algorithm for three-dimensional location of nerves in tissue. It was found that the original approach proposed to three-dimensional modeling would not work since it was based on a finite difference model that would not be effective for Nervonix purposes. Consequently, a major focus of the project became the development of a descriptive model of how electrical fields move through living tissue, the "forward model".

The grant allowed employment of three summer interns over the course of the project. These individuals accomplished several important goals:

- Reverse engineering of an earlier prototype device, a step that allowed nerve position data collection for export to MatLab and Excel.
- Discovery of tissue frequency and waveform dependencies that allowed enhanced resolution of nerve-rich and nerve-poor regions.
- Experimental description of the behavior of insulated needles in electrolytes and tissue.
- Experimental description of electrical circuits that mimic tissue behavior and the effect of pre-conditioning applied output waveforms on tissue electrical behavior.

Work continues to formalize the mathematical algorithm for depicting nerves in three dimensions. Development of a more complete description of electrical field movement through tissue and the varying properties of nerves in response to applied electrical fields facilitates this effort and affords many potential spin-off commercial applications, including new imaging approaches, modifications of existing imaging technologies, and improvement of related medical technologies already in use but not fully optimized.

Commercialization Plan:
Value Proposition: The Nervonix Nerve Imaging Technology helps medical professionals locate and determine the condition of peripheral nerves for diagnosis, treatment and documentation. This is not possible with currently available imaging modalities. The location and condition of peripheral nerves are determined through the application of extremely low intensity electrical fields. The Nervonix products will be based on the "razor-razor blade" model with a reusable component and a disposable component.

Product Description:
The Nervonix Nerve Imaging Technology is the basis for a flexible line of multiple nerve imaging products that can be implemented in several configurations to address different markets, applications, and anatomy.

The basic offering is a sensor system applied to the skin surface. Software plugged into the sensor system translates measurements in the form of an image on any laptop computer and/or hand-held imaging device.

Target Market:
The Nervonix Nerve Imaging products will address the Regional Anesthesia, Pain Management and Surgical Nerve protection markets, an estimated available 2005 market at $1.6 billion (United States) and $3.2 billion (worldwide). Initial users for the technology will include anesthesiologists, pain management specialists and surgeons.

Marketing Strategy:
Because management believes a highly capable commercial partner will reduce risk as this new technology enters the market, it is in the process of selecting a strategic medical device partner with established distribution channels, marketing ability, and sales processes in the Nervonix target markets. The strategic partner will be key to implementing all facets of launching the first product, including decisions regarding manufacturing, reimbursement strategy, and sales and marketing.

The company has outsourced prototype development to a product development firm. Nervonix received delivery of four prototype systems in October 2004.

Commercial device development will be in conjunction with an appropriate medical device company. Nervonix is currently in discussion with potential commercial partners who are positioned to move its technology into the medical marketplace.

Management has retained a regulatory counsel. Regulatory strategy will dictate any clinical studies, which will begin after a strategic partner has been selected.

Production or Manufacturing Plan:
Nervonix expects that final manufacturing of its first products will be outsourced. In time, at least some of the manufacturing functions, such as assembly, may be retained within Nervonix.

Economic Impacts:

Estimate of Sales Revenues for Five-Year Period into the Future:

- ***New Businesses Created or Expanded***

Nervonix has expanded its business during the time of this grant. Operations functions were moved to Longmont, Colorado, employing 3.5 F.T.E. and R&D functions are focused in Bozeman, employing 1.75 F.T.E. StrategixID, a Bozeman company, is engaged in prototype development under a second MBRCT grant. Student interns were highly successful and the experience will influence consideration of local students and graduates to fill Nervonix positions in the future.

- ***Acquisition of Investment Capital***

Significant investment has occurred in Nervonix during the tenure of a new CEO beginning in April 2004, establishing both private and institutional investment.

- ***Other***
  - The Nervonix prototype is being demonstrated to thought leaders in the regional anesthesia field as a preliminary step for commercialization.
  - Positive feedback is being obtained from the industry thought leaders based on demonstration of the Nervonix Nerve Imaging System.

#03-26 Establish Research in the Biogeochemistry and Biological Effects of Toxic Metals from Historic Mining Activities

Kumar Ganesan – Montana Tech, Butte

Final report approved May 2006

Summary:

The main objective of the project was to improve research capabilities of Montana researchers to become nationally competitive and was accomplished by two specific research projects funded by the EPA and MBRCT. The University of Montana project studied diversity, structure, and function of microbial communities in riverine systems contaminated by multi-component metals and the Montana Tech project examined the chemical process responsible for diel metal fluctuations in streams contaminated with toxic metals. Participating research faculty members are successfully involved in research and publications primarily due to the funding through this MBRCT/EPA-EPSCoR program. The program has been the catalyst for a three-fold increase in funding received on a competitive basis.

Commercialization Plan:

The project does not represent a product or service in terms of commercialization. However, the techniques developed to identify microbial communities in mine-contaminated sites could be used in other similar areas.

Economic Impacts:

The project has brought more than three times the original funding to Montana from other sources. This improvement in the capabilities of scientists to compete nationally and obtain additional grants is considered a successful investment in the future of Montana. Publications and presentations significantly improve the visibility of Montana in science and engineering research.

Patents applied for or granted:

Montana Tech has filed a patent for the mercury removing device and method for removing mercury vapor from a gas stream with a metallic filter.

Unique features/success stories/news clippings, brochures/other information:

The Final Report includes two articles written by various members of the research team. "Structural and Seasonal Dynamics of Hyporheic Zone Microbial Communities in Free-Stone Rivers of the Western Unites, was published by *Microbial Ecology's* online publication June 13, 2003. "Seasonal Dynamics of Shallow-Hyporheic-Zone Microbial Community Structure along a Heavy-Metal Contamination Gradient," was published by *Applied and Environmental Microbiology*, April 2004. A 43-page Abstract discussing studies regarding the rates of change in hyporheic microbial communities in response to heavy metal contamination is also included in the report.