Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 022-A**

Advancing the Forest Bio-Economy in Minnesota

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 834,015

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

Proposed work provides information and decision making tools to attract advanced wood products and bio-economy industry to Minnesota; fostering economic growth, ensuring forest harvest, sustaining industry and environmental needs.

Name: Eric Singsaas

Sponsoring Organization: U of MN - Duluth NRRI

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Location

Region: Central, Northeast

County Name: Aitkin, Carlton, Cass, Cook, Crow Wing, Isanti, Itasca, Kanabec, Koochiching, Lake, Mille Lacs, Morrison, Pine, St. Louis

City / Township:

Alternate Text for Visual:

Project Information flow, showing integration of remotely-sensed and field inventories of forest lands with biochemical characterizations to provide economic, social and environmental benefits.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Advancing the forest bio-economy in Minnesota

I. PROJECT STATEMENT

Through legislative and executive actions, Minnesota has made a long-term commitment to develop and attract a renewable biofuel and bio-based chemicals industry. These commitments provide an excellent opportunity for economic development and job creation in our northern forest region, which has been hit hard by the decline of the paper, wood products, and mining sectors. It is possible to pursue these goals while preserving our natural resources and ensuring long-term economic viability of our forest products industry. In order to achieve these goals, we must: 1) ensure that forests do not become over-harvested, 2) preserve the ecosystem services that our forests provide, and 3) better understand feedstock flexibility and economic impact of new technologies in the context of existing industry. This proposed work will provide data and decision making tools to public and private land managers to help foster the development of the 21st century bio-economy by 1) assessing the availability of forest resources; 2) predicting how future management decisions and climate change will affect wood availability; 3) developing understanding of the potential for conversion of the forest resources into bio-based chemicals and advanced biofuels; 4) quantifying the value of forest ecosystem services; and 5) comparing the potential value of our forest resources to the state as standing forests with existing and emerging industry.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Characterize distribution and productivity of forest tree species **Budget: $398,303**

We will acquire and process recent Landsat imagery to update our species-level forest classification for northeastern Minnesota. We will leverage the public's investment in the statewide 2011 LiDAR collection to develop algorithms that link remotely-sensed data to forest stand densities, stand stocking, and biomass volumes. These will be used to develop models for predicting forest productivity across all forestlands. The resulting map will be input to the LANDIS landscape model that will project future forest conditions under a range of management and future climate scenarios.

Outcome	Completion Date
1. Updated remote sensing species classification	Sept. 2018
2. LiDAR analysis of volume and biomass	Sept. 2018
3. Productivity modeling and ground-truthing	June 2019
4. Project future forest conditions under different climate and management scenarios	June 2019
5. Integrate above projects into a current and future forest resource dataset	Dec. 2019

Activity 2: Characterize raw material suitability for emerging industry **Budget: $287,962**

We will acquire samples of five major forest species (quaking aspen, red pine, balsam fir, black ash and paper birch) as well as hybrid poplar within three different size classes: < 6" DBH boles, pulpwood 6-10" DBH, and forest harvest residues. We will chip this material and extract the lignin, cellulose, and hemicellulose fractions at a pilot plant facility. The hemicellulose extractives will be characterized by gas chromatography and the lignin components will be characterized by FTIR and NMR spectroscopy. Cellulose fractions will be enzymatically hydrolyzed and fermented to ethanol.

Outcome	Completion Date
1. Extractive chemicals and lignin characterization for six major species x three size classes	Sept. 2018
2. Hydrolysis and fermentation potential of six forest species x three size classes	Dec. 2018
3. Integrate above products into a chemical resource dataset	March 2019
4. Match processing technology platforms with resource chemical characteristics	Dec. 2018
5. Map chemical processing potential by species across state for biorefinery siting potential	Dec. 2019

Activity 3: Characterize distribution and value of forest-related ecosystem services **Budget: $28,075**

To maintain a sustainable forest bioeconomy, the ecosystems services provided by forests – carbon storage,

water and air purification, wildlife habitat, recreation, and numerous others – must be maintained. We will quantify the ecosystem services provided by the specific forest types noted above and provide both market and non-market (e.g., social value) valuations of these services. The type and degree of ecosystem services vary across forest types; we will map the spatial distribution of services and use this information in determining optimal uses of forests across the landscape.

Outcome	Completion Date
1. Quantify ecosystem services associated with forested landscape	June 2019
2. Quantify market and non-market valuation of services	Sept. 2019
3. Map ecosystem services distribution and value	Dec. 2019

Activity 4: Analyze optimal and sustainable economic potential for forest-based industry **Budget: $55,514**

We will analyze the impact of new wood-using technology and industry to Minnesota's economy. We will integrate data from activities 1-3 into a well-documented economic impact model to estimate direct and induced effects, including jobs and tax revenue. We will also evaluate issues related to the logistics and procurement of raw material.

Outcome	Completion Date
1. Evaluate cost and logistics of wood procurement from forest to mill	Dec. 2019
2. Evaluate cost profile of different bio-based industry technology platforms	March 2020
3. Quantify value of bio-based chemical industry products	March 2020
4. Compare relative value-add between current and potential future forest products industry	June 2020

Activity 5: Assess economic and ecological outcomes of forest management and economic development decisions. **Budget: $64,161**

We will integrate activities 1-4 into a spatial model that allows industries and decision makers to weigh the costs and benefits of new technology based on current and future resource availability, transportation distances, economic value and maintenance of ecosystem services.

Outcome	Completion Date
1. Create the decision model	June 2020
2. Deploy the model on a University of Minnesota web server	June 2020
3. Conduct outreach and training sessions in model use, present and publish results	June 2020

III. PROJECT STRATEGY

A. Project Team/Partners

Eric Singsaas; NRRI; Overall project management and biomass chemical analysis lead. Bill Berguson; NRRI; Lead forest species characterization and forest field work. George Host; NRRI; Lead LiDAR and Landsat-based forest characterizations. Lucinda Johnson; NRRI; Lead ecosystem services modeling.

B. Project Impact and Long-Term Strategy

The long-term goal of this project is to bring truly sustainable economic development to Minnesota's forested regions. The outcomes of this project will support a forest products industry that can sustain the ecological services of the state's forests while simultaneously sustaining family-supporting jobs and economic growth of the region. One major product will be contemporary characterization of available forest resources and a forecast of future wood availability to industry. Another outcome will be to attract and support an industry consortium that provides sustained economic development to Minnesota's forested regions.

C. Timeline Requirements

This project will require three years. The first two years will comprise the bulk of the field and laboratory analyses. In year three we will compile data and models for reporting to Minnesota's stakeholders.

2017 Detailed Project Budget

Project Title: Advancing the forest bio-economy in Minnesota

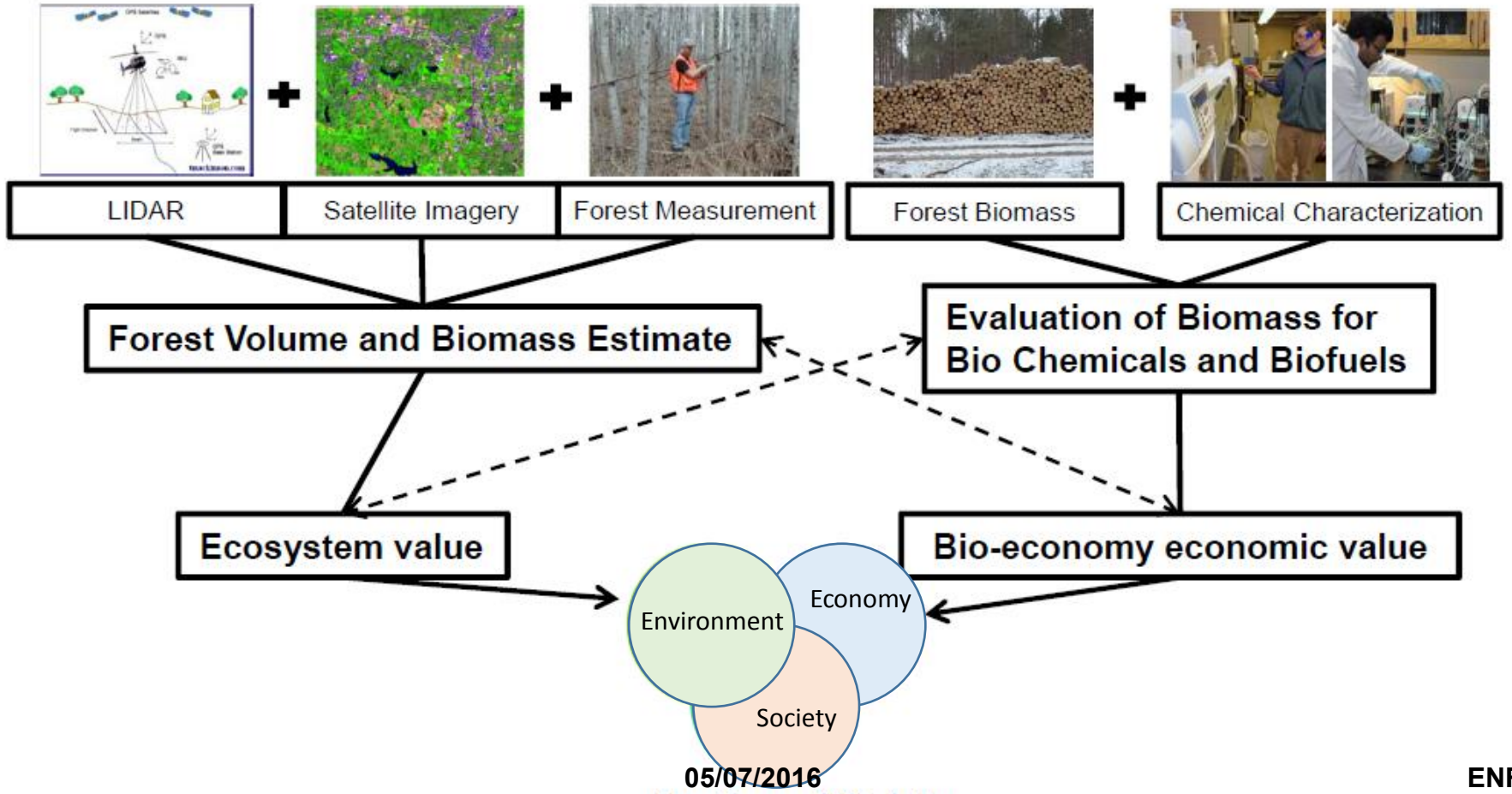
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Eric Singsaas, Project manager (66.3% salary, 33.7% benefits); 20% FTE each year for 3 yrs	$ 100,463
G. Host & L Johnson, co managers (66.3% salary, 33.7% benefits); Host 15%/15%/15% , Johnson 4%/2%/2%, FTE each year for 3 yrs	$ 84,436
B. Berguson, forest productivity analyses (66.3% salary, 33.7% ben); 15% FTE each year, 3 yrs	$ 63,385
P. Meysembourg, assist w/ remote sensing classification (66.3% salary, 33.7% benefits); 30% FTE each year, 3 yrs	$ 80,062
D. Buchman, coordinating forest measurement & data collection (72.6% salary, 27.4% benefits); 30% FTE each year, 3 yrs	$ 71,377
3 ppl, chemical analysis of wood products (66.3% salary, 33.7% benefits); 1 @ 30% FTE each year for 3 years, 2@ 20% FTE each year, 3 yrs	$ 141,419
2 field techs (72.6% salary, 27.4% benefits); 10% FTE each year, 3 yrs	$ 26,681
2 ppl (M. Haynes + TBD) for economic modeling of forest harvest, (66.3% salary, 33.7% benefits); each person 5% FTE each year, 3 yrs	$ 32,564
Undergrad student, assist with fieldwork (100% salary); 80% summers, yr 1 and 2	$ 19,639
Professional/Technical/Service Contracts:	
Cellulous Pilot & Processing Lab, chemically fractionating forest prod @ $150/hr, yrs 1 and 2	$ 64,800
Local forestry consultant group (TBD), field measurement of forest plots, 150 site @ $266/site, yrs 1 and 2	$ 40,000
University of Iowa, Dr. Wolter, assembling and processing species-level satellite data for forested region of northern Minnesota, $17,122 each year, 3 yrs	$ 34,728
Equipment/Tools/Supplies:	
Equipment: Amperimetric detector, used for carbohydrate analysis	$ 7,480
Lab supplies for chemists, $4,000 yrs 1 and 2, $2,000 yr 3	$ 10,000
Lab supply: Chromatograph column	$ 1,486
Field supplies ($1200 yr 1) & data storage ($200 each year, 3 yrs)	$ 1,800
Travel:	
New industry assistance: 25 trips, 150 mi avg @ $0.54 each year, 3 yrs	$ 6,075
MSP mtgs, Bioeconomy coalition, 6x/yr-$140 lodg, $74 per diem, 320 mi=$2321 ea year, 3 yrs	$ 6,963
Conferences to present: 2 ppl, different conferences in MSP - per person: mileage $173 (320 mi * $0.54) + lodging $280 (2 nights* $140/night*1 room) + per diem $148 ($74/day*2 days assuming some meals provided) + registration $200, yrs 2 and 3	$ 4,300
Fieldwork: **a)** remote sensing $2,924 each year, 3 yrs ($0.54* 80mi/day + $10 truck fee*20 days=$1064, $34 per diem*20 days*2ppl=$1360, $25 campsite*20 nights=$500), **b)** NE MN fieldwork $11,400 each year, yrs 1 and 2 ($3000 truck lease + $51 per diem*2 ppl*30days + $89 lodg*30 nights*2 rms)	$ 31,572
Additional Budget Items:	
GIS lab fees ($4.10/hr for ~600 hrs)	$ 2,460
Outreach training, yr 3; all-day training session at NRRI w/ 40 trainees+7 project ppl@ $15 ea for lunch ($705) + $1620 mileage reimbursement (20 cars, 150 mi avg RT*$0.54)	$ 2,325
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 834,015

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row*

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *MN Power, "Red Pine LiDAR analysis"*	$ 25,000	*Pending*
Other State $ To Be Applied To Project During Project Period	N/A	
In-kind Services: Unrecovered indirect (MTDC, excluding equipment, 53% rate 7/1/17-6/30/18; 54% 7/1/18-6/30/20)	$ 443,326	Secured
Funding History	N/A	
Remaining $ From Current ENRTF Appropriation:	N/A	

PROJECT CONCEPT AND INFORMATION FLOW



LCCMR 2017 LCCMR Project Manager Qualifications and Organization Description
Eric L Singsaas, Natural Resources Research Institute, University of Minnesota Duluth

Key Qualifications
Dr. Singsaas is Bio-Economy and Wood Products director at the Natural Resources Research Institute. He is a plant physiologist and biochemist who studies biological hydrocarbon production and forest product utilization. He has a B.A. in Biology and Chemistry from Concordia College, Moorhead, MN and a Ph.D. in Botany and Plant Biochemistry from the University of Wisconsin – Madison. As an associate professor of biology at the University of Wisconsin – Stevens Point he co-developed the Wisconsin Institute for Sustainable Technology to foster the development of a bio-based economy based around use of renewable natural resources. He holds several patents in biorefinery and biofuels technology.

Education: April. 1998 – March. 2000: Postdoctoral (Plant Biology), University of Illinois
Nov. 1992 – Oct. 1997: PhD (Botany), University of Wisconsin – Madison

Selected Grants
2009-2013 US Army Research Lab. R Champeau, A Manesh, E Singsaas, D Guay. *Sustainable Alternative Energy for the Department of Defense.* Phase I funded: $150,000, Phase II Funded: $2,400,000, Phase III Funded: $1,700,000.

2012 D Mead P Brumm and E Singsaas. *Improved Microbial Production of Hemiterpenoids for the Biorefinery.* USDA National Institute for Food and Agriculture SBIR. $221,000. Collaborative Proposal with C5-6 Technologies.

2013 E Singsaas. *Cellulose Pilot and Processing Lab.* University of Wisconsin System Economic Development Incentive. $2,835,000.

2014 E Singsaas. Commercializing Biomass Fractionation Technology in Central Wisconsin. University of Wisconsin – Ideadvance Phase 1. $25,000

2015 E Singsaas. *AABT: Commercializing Algal Carbon Capture for the Ethanol Industry.* University of Wisconsin Center for Technology Commercialization SBIR-Advance. $75,000

Selected Publications:
Singsaas E. (2012). Paper chain: Researchers at a University in Wisconsin are producing isoprene from cellulose. Will the paper industry enter the tire and rubber supply chain?" *Tire Technology International* April 2012.

Singsaas E (2014) Die Suche nach erneuerbarem Isopren. *Gummi Fasern Kunststoffe* 4/2014, 224-228.

Runge T, Zauche T, Baxter C, **Singsaas E** and Alkasrawi M (2014) *Classroom Materials for Bioenergy Education.* Wisconsin Energy Institute. https://energy.wisc.edu/education/classroom-materials

Gurram RN, Lecher NJ, Duncan SM, **Singsaas EL**, Al-Shannag M and Alkasrawi M (2015) Bioconversion of paper mill sludge to bioethanol in the presence of accelerants and hydrogen peroxide pretreatment. *Bioresource Technology* 192, 529-539.

Alkasrawi M, Al-Hamamre Z, Al-Shannag M, Abedin MdJ and **Singsaas E** (2016) Conversion of Paper Mill Residuals to Fermentable Sugars. *BioResources* 11, 2287-2296.

The Natural Resources Research Institute is a part of the University of Minnesota Duluth. Its mission is to promote private sector employment based on natural resources, in an environmentally sensitive manner. NRRI scientists have extensive experience in managing large, interdisciplinary projects with objectives that include the development of new processes and products from renewable natural resources. Commercial development of these processes promote economic development based on sustainable use of Minnesota's natural resource base.