

10-23-2014

# REU Site: Explore It! Building the Next Generation of Sustainable Forest Bioproduct Researchers

David Neivandt

*Principal Investigator; University of Maine, Orono, dneivandt@umche.maine.edu*

Darrell W. Donahue

*Co-Principal Investigator; University of Maine, Orono, ddonahue@umche.maine.edu*

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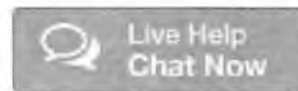
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## Recommended Citation

Neivandt, David and Donahue, Darrell W., "REU Site: Explore It! Building the Next Generation of Sustainable Forest Bioproduct Researchers" (2014). *University of Maine Office of Research and Sponsored Programs: Grant Reports*. 41.  
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## Preview of Award 1063007 - Final Project Report

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### Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1063007
Project Title:	REU Site: Explore It! Building the Next Generation of Sustainable Forest Bioproduct Researchers
PD/PI Name:	David Neivandt, Principal Investigator Darrell W Donahue, Co-Principal Investigator
Recipient Organization:	University of Maine
Project/Grant Period:	09/15/2011 - 08/31/2014
Reporting Period:	09/01/2013 - 08/31/2014
Submitting Official (if other than PD\PI):	David Neivandt Principal Investigator
Submission Date:	10/23/2014
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	David Neivandt

### Accomplishments

#### \* What are the major goals of the project?

The major goal of the project is to create the next generation of sustainable forest bioproduct researchers through providing them with an outstanding and relevant research experience.

#### \* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

Major Activities: (Jordan Sanders) Nanofibrillated cellulose was treated with three different silane functionalities. These cellulose particles show potential as reinforcement for future sustainable use in thermoplastic composites. Before use, cellulose nanofibrils were dried using a spray drying process. Spray drying is the preferred drying method for cellulose nanoparticles because of the process flexibility in particle sizing, overall manufacturing process, cost, and low labor requirements. Previous studies have optimized the nanocellulose spray drying

method, leading to its preferential use in manufacturing because of morphology, sustainability and chemical treatment.

(Elizabeth Crute) Life cycle assessment is a common methodology for analyzing the environmental impacts of a product or product system. Environmental, economic, and policy incentives have encouraged the production of forestry biofuels, especially in Maine, a national leader in forestry products. Specifically, after the passing of the Renewable Fuel Standard (RFS), a market for biofuels was created. To meet the RFS and the definition of renewable biomass, sustainability is a large factor. This project benefits Maine's forestry sector and the environment since the field depends on the success of the environment. It contributed to the assessment the overall LCA of producing biodiesel from harvesting residues.

(Leah Jones) Using literature analysis, the policies for reducing environmental changes can be understood, examined, and ultimately compared to one another. In addition, an analysis of how renewable energy sources, particularly woody biomass, compare to the carbon credit allowances in both the US and the EU can be made. Based on current studies, there is a lack of connectivity between science and policy, and even the existing legislation tends to be discontinuous between US states and EU countries.

(Anna Moh) Biofuels are ideally an energy-dense fuel derived from biomass. They can be derived through many processes, one of which involves an acid-catalyzed hydrolysis and dehydration process at high temperature, pressure, and acid concentration. This process converts cellulose to levulinic acid, which can be upgraded to an energy dense fuel. Historically, the acid used to catalyze this process is sulfuric acid. To dispose of sulfuric acid, it must be neutralized and its resulting salt must be put in a landfill. This proves inefficient and unsustainable because of the cost of the acid, base, and landfilling procedure. A more easily recycled acid circumvents the drawbacks of this process by reverse synthesizing into its original components, thus allowing for reuse rather than disposal.  $\alpha$ -hydroxysulfonic acids ( $\alpha$ -HSAs) are a promising category of acids that have been studied for their recyclable properties in biofuel production.

(Joel Strothers) Formaldehyde is a harmful gas that is emitted from wood-containing building products such as plywood, particleboard and oriented strand board. Typically, the formaldehyde comes from the adhesives used in producing these products. There is concern, however, that even when the formaldehyde-containing adhesives are not used, formaldehyde is still emitted from the wood itself. A study involved analyzing the moisture content and formaldehyde emissions of aspen and southern pine untreated wood strand samples at several temperatures, using wet chemistry and gas chromatography/ mass spectrometry (GC/MS).

(Edward Fratto) A co-precipitation mechanism was used to generate iron oxide particles which were then mechanically stirred into nanocellulose gel. After drying, the new composite material was tested both mechanically and via X-ray CT scanning.

(Hans Kulenkampf) Three different heat rates were used in cellulose nanofiber carbonization. The carbon yield was measured and the carbonized samples

were characterized using X-ray photoelectron spectroscopy, Scanning electron microscopy and Energy Dispersive X-ray analysis.

(Lina Rodriguez) A case study examining co-combustion of coal and biomass was performed at the Unit of Technological Development of the University of Concepcion, (UDT- UDeC), where there are two pilot plants for the combustion processes being analyzed.

(Luz Alejo) Recently interest in lignin bio-oils has increased as a potential contributor in phenol-formaldehyde (PF) resin synthesis (as partial substitute of phenol). Bio-oils are too complex to easily characterize the polymerization reaction. Temperature, pH, and different formaldehyde/phenol ratios in feedstock under which phenols with formaldehyde polymerize have a profound effect on the characteristics of the resulting resins. Characterization was performed using Fourier Transform Infrared Spectroscopy (FTIR) to analyze the chemical structure. Differential Scanning Calorimetry (DSC) was used to study the thermal properties of the curing of the resins.

(Zuleyka Marquez) Sheet-like structures of lignin were produced using an ice templating procedure and incorporated into paper barrier coatings. Barrier properties including water vapor and grease resistance were determined and compared to uncoated paper.

(Luke Yarnall) Characterized antimicrobial poly(ethylene-co-vinyl acetate)/copper nanoparticle composites

Specific Objectives: Surface silane treatments of cellulose nanofibrils were tested to promote adhesion to polymer matrices with a goal of optimum utilization in thermoplastic composites.

The LCA of three different tree harvesting methods with respect to using harvesting residues for biofuel in the Northeast was undertaken. Harvesting methods examined included whole tree, cut-to-length, and tree length.

The policies for reducing greenhouse gas emissions and increasing renewable energy usage between the U.S and European Union were studied.

A selection of potential carbonyls that could create an appropriate  $\alpha$ -HSA for biofuel synthesis was undertaken.

The source of formaldehyde stemming from untreated wood as a function of wood species, moisture content and temperature was studied.

Iron oxide ( $\text{Fe}_2\text{O}_3$ ) nanoparticles were generated and incorporated into a nanocellulose bioplastic matrix as contrasting agents for medical imaging.

Cellulose nanofibers containing 1, 2 and 3% solids and cellulose nanocrystals containing 11.8% solids content were freeze-dried and then carbonized in an inert atmosphere to produce different carbon structures.

Life Cycle Assessment using software SimaPro 7.2 and impact assessment model CML 2 baseline 2000 were used to evaluate the environmental impacts of biomass torrefaction and coal with biomass co-combustion.

To determine optimal conditions of the reaction, and analyze the structure of the bio-oil

phenolic resins, bio-oil and an extraction of this bio-oil were mimicked and utilized.

Lignin was utilized to create barrier coatings from renewable resources.

Ethyl vinyl acetate copolymer (EVA)/copper nanoparticle (CuNP) composites were prepared by melt processing and evaluated for antimicrobial activity as well as characterized mechanically, thermally and rheologically.

**Significant Results:** It was discovered the particle yield from spray drying averaged 25% for the CNF suspension examined, average particle size distribution didn't change and CNF morphology showed some aggregation of larger particles along with many small twisted rectangular particles.

LCA results indicate that the cut-to-length harvesting method is the most sustainable approach in removing wood from the forest in Maine.

A larger connection to scientific study and a more universal implementation of policies is needed to make the greenhouse gas reduction and renewable energy increase effective in the EU and the US.

High pressure liquid chromatography results showed that of the three  $\alpha$ -HSAs synthesized from 4-methyl-2-pentanone, 2-butanone, and acetone, the 2-butanone and acetone  $\alpha$ -HSAs showed the most promise in terms of reversion to their original compounds, whereas the 4-methyl-2-pentanone  $\alpha$ -HSA degraded rapidly under thermal stability testing.

It was concluded that wood with higher moisture contents and elevated temperatures release more formaldehyde.

The resultant iron oxide-nanocellulose composite polymer is lightweight but strong, biocompatible, and visible via X-ray imaging, making it an attractive alternative to metal implant material.

The carbon structures produced from CNF remained the precursor's structure; amorphous and tangled fibers in CNF's case and parallel layers in CNC's case. Graphite was found using the XPS in the samples obtained from the slow and medium carbonization of CNC. The CNC samples contain sodium, which likely comes from the acid hydrolysis and neutralization steps required to produce the crystals. Different structure were found above the layers in the medium carbonization's samples; carbon nano fibers, hexagonal carbon crystals, agglomerated carbon spheres and Na particles.

The results showed that, compared with coal, using torrefied biomass as a fuel reduced environmental impacts on four out of the five categories investigated. In addition, combustion of coal with natural biomass indicated a reduction in all the environmental indicators studied, suggesting that using fuels such as biomass in a co-combustion process helps to reduce environmental impacts while maintaining efficiency.

There is the opportunity to mimic a whole bio-oil and extract derived from fast pyrolysis. GC and <sup>13</sup>C NMR were used to determine a composition for the mimics. By using the mimics and chemical and thermal characterizations we may conclude that the mimics are somewhat similar to phenolic resins and that the whole bio-oil and extract may be suitable for a whole replacement for phenol.

The lignin-based barrier coatings also demonstrated significantly superior barrier properties against grease compared to commercially available paper.

Copper nanoparticles in oxidized and valence zero states were found to influence neither mechanical and rheological properties nor thermodegradation behavior of EVA at loading levels of one percent by weight or lower. Copper nanoparticle composites represent an effective way of adding antimicrobial activity to EVA without altering the polymer's physical properties.

Key outcomes or see above

Other achievements:

**\* What opportunities for training and professional development has the project provided?**

Jordan Sanders developed skills in the silane modification and spray drying of cellulose nanofibrils using a bench scale spray dryer. He gained analytical experience in scanning electron microscopy and particle size analysis using laser diffraction.

Elizabeth Crute gained experience in life cycle analysis of wood harvesting systems in the state of Maine using Simpro LCA software

Anna Moh developed skills in the study of potential carbonyls that could create an appropriate  $\alpha$ -hydroxysulfonic acid for biofuel synthesis.

Leah Jones gained experience in comparative analysis of environmental regulations between the U.S. and European Union via a comprehensive literature analysis and developed skills in wood fuel pellet analysis techniques.

Luke Yarnall developed skills in the manufacture and testing of copper nanoparticle –ethylene vinyl acetate composites.

Zuleyka Marquez developed skill in the manufacture of lignin fibers and their incorporation in barrier coatings for packaging manufacture

Lina Rodriguez developed skills in life cycle assessment of coal-biomass energy co-generation on a pilot scale combustion plant

Hans Kulenkampf gained experience in the manufacture and analysis of carbon structures produced from the pyrolysis of nanocellulose materials

Luz Alejo developed skills in producing and analyzing phenolic resin precursors from the fast pyrolysis of lignin bio oils.

Joel Strothers developed skills in measuring formaldehyde emissions from native wood as a function of moisture content and temperature.

Edward Fratto developed skills in manufacture and testing of iron oxide nanoparticles and their incorporation in nanocellulose composites.

**\* How have the results been disseminated to communities of interest?**

The conclusion of the REU program culminates in a one day research conference in Chile where the participants present the results of their work to the faculty and staff at UDT-University of Concepcion and the conference is streamed via internet to the University of Maine to mentors and graduate students. In addition, the results of the work are summarized and uploaded to the FBRI website. The RET portion of the program is shared among middle school science teachers in the state of Maine and beyond. If appropriate, portions of the participant's research may also be presented at technical conferences (regional, national and international) and/or included in scientific proceedings or peer reviewed journal articles. One of the REU faculty mentors and an REU student participant are attending the annual REU Symposium in Arlington, VA (Oct 2014) to present a poster on representative research work.

## Products

### Books

### Book Chapters

### Conference Papers and Presentations

Bautista, I. Y. Peng, and D. J. Gardner (2014). *Cellulose-Based Polypropylene: Extensional Flow Mixer vs. Twin-Screw Extruder*. Ronald E. McNair Symposium. North Carolina. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Rodríguez –Velázquez, A., Weiskittel, A., and Frank, J. (2014). *Comparison of equations for calculating biomass in temperate forests and tropical dry forests*. HENAAC National Conference. New Orleans LA. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Demers AL, Marquez Z, Bousfield DW, Neivandt DJ. (2014). *Ice-templated Lignin in Barrier Coatings*. TAPPI Advanced Coatings Fundamentals Symposium. Minneapolis MN. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gardner, D. J. and D. Neivandt (2014). *Implementation of an International Component Bolsters Student Interest, Engagement and Diversity in an REU Program*. REU Symposium. Arlington VA. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Melanie Blumentritt, Sasha Howes and Stephen M. Shaler (2014). *Life Cycle Assessment of Torrefied Wood Pellet Production in Millinocket, Maine*. NESAF Annual Meeting. Nashua, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Richmond F. C. Haugwout, and D.W. Bousfield (2014). *The Use of Cellulose Nanofibers in Paper Coating Formulation*. PAPERCON. Nashville TN. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

### Inventions

### Journals

Case, P.A. ; Bizama, C. ; Sugura, C. ; Wheeler, M.C. ; Berg, A. ; DeSisto, W.J. (2014). *Pyrolysis of Pre-Treated Tannins Obtained from Radiata Pine Bark*. *Journal of Analytical and Applied Pyrolysis*. 107 250. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Demers AL, Marquez Z, Bousfield DW, Neivandt DJ. (). *Ice-Templated Lignin in Barrier Coatings*. *TAPPI*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Melanie Blumentritt, Sasha Howes and Stephen M. Shaler (2014). *Life Cycle Assessment of Torrefied Wood Pellet Production in Millinocket, Maine*. *Biomass and Bioenergy*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Peng, Y., S. A. Gallegos, D. J. Gardner, Y. Han and Z. Cai. (2014). Maleic Anhydride Polypropylene Modified Cellulose Nanofibril Polypropylene Nanocomposites with Enhanced Impact Strength. *Polymer Composites*. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/pc.23235

Vassiliev, T. ; Neivandt, D.J. (). Let Them Eat Cake...OE Cake!. *Science Scope*. Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

### Licenses

### Other Products

### Other Publications

### Patents

### Technologies or Techniques

### Thesis/Dissertations

### Websites

## Participants/Organizations

### Research Experience for Undergraduates (REU) funding

Form of REU funding support: REU site award

How many REU applications were received during this reporting period? 140

How many REU applicants were selected and agreed to participate during this reporting period? 12

REU Comments:

### What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Neivandt, David	PD/PI	1
Donahue, Darrell	Co PD/PI	1
Arteaga, Luis	Faculty	1
Bousfield, Douglas	Faculty	1
Cole, Barbara	Faculty	1
Fort, Raymond	Faculty	1
Gardner, Douglas	Faculty	1



<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Gramlich, William	Faculty	1
Mason, Michael	Faculty	1
Miranda, Cristian	Faculty	1
Rice, Robert	Faculty	1
Rubin, Jonathan	Faculty	1
van Walsum, Peter	Faculty	1
Weiskittel, Aaron	Faculty	1
Vassiliev, Tracy	K-12 Teacher	1
Alejo, Luz	Research Experience for Undergraduates (REU) Participant	3
Crute, Elizabeth	Research Experience for Undergraduates (REU) Participant	3
Fratto, Edward	Research Experience for Undergraduates (REU) Participant	3
Jones, Leah	Research Experience for Undergraduates (REU) Participant	3
Kulenkampff, Hans	Research Experience for Undergraduates (REU) Participant	3
Marquez, Zuleyka	Research Experience for Undergraduates (REU) Participant	3
Moh, Anna	Research Experience for Undergraduates (REU) Participant	3
Rodreguez, Adolfo	Research Experience for Undergraduates (REU) Participant	3
Rodriguez, Lina	Research Experience for Undergraduates (REU) Participant	3
Sanders, Jordan	Research Experience for Undergraduates (REU) Participant	3

Name	Most Senior Project Role	Nearest Person Month Worked
Strothers, Joel	Research Experience for Undergraduates (REU) Participant	3
Yarnall, Luke	Research Experience for Undergraduates (REU) Participant	3

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**Full details of individuals who have worked on the project:**
**David Neivandt****Email:** dneivandt@umche.maine.edu**Most Senior Project Role:** PD/PI**Nearest Person Month Worked:** 1**Contribution to the Project:** Program Director**Funding Support:** NSF**International Collaboration:** No**International Travel:** Yes, Chile - 0 years, 0 months, 7 days

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**Darrell W Donahue****Email:** ddonahue@umche.maine.edu**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 1**Contribution to the Project:** Co-Director**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**Luis Arteaga****Email:** l.arteaga@udt.cl**Most Senior Project Role:** Faculty**Nearest Person Month Worked:** 1**Contribution to the Project:** Mentor**Funding Support:** Chilean**International Collaboration:** Yes, Chile**International Travel:** No

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**Douglas Bousfield****Email:** bousfld@maine.edu

**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Barbara Cole**

**Email:** Barbara\_Cole@umit.maine.edu

**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Raymond Fort**

**Email:** rfort@maine.edu

**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Douglas Gardner**

**Email:** Douglas\_Gardner@umit.maine.edu

**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Senior Personnel. International Program Coordinator.

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** Yes, Chile - 0 years, 0 months, 7 days

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**William Gramlich**

**Email:** william.gramlich@maine.edu

**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Michael Mason**

**Email:** mmason@umche.maine.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Cristian Miranda**

**Email:** c.miranda@udt.cl

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** Chilean

**International Collaboration:** Yes, Chile

**International Travel:** No

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**Robert Rice**

**Email:** robert\_rice@umit.maine.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**international Collaboration:** No

**International Travel:** No

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**Jonathan Rubin**

**Email:** rubinj@maine.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No  
**international Travel:** No

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**Peter van Walsum**

**Email:** pvanwalsum@umche.maine.edu  
**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Aaron Weiskittel**

**Email:** aaron.weiskittel@maine.edu  
**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Mentor

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Tracy Vassiliev**

**Email:** tvassiliev@bangorschools.net  
**Most Senior Project Role:** K-12 Teacher  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Research Experience for Teachers Participant

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Luz Alejo**

**Email:** lualejo@udec.cl  
**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Chilean exchange REU student

**Funding Support:** Chilean

**International Collaboration:** Yes, Chile  
**International Travel:** Yes, United States - 0 years, 2 months, 8 days  
**Year of schooling completed:** Other

**Home Institution:** University of Concepcion  
**Government fiscal year(s) was this REU participant supported:** 2014

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**Elizabeth Crute**

**Email:** ecrute1@uga.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** Yes, Chile - 0 years, 0 months, 7 days

**Year of schooling completed:** Junior

**Home Institution:** University of Georgia

**Government fiscal year(s) was this REU participant supported:** 2014

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**Edward Fratto**

**Email:** Edward\_Fratto@student.uml.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** Yes, Chile - 0 years, 0 months, 7 days

**Year of schooling completed:** Junior

**Home Institution:** University of Massachusetts Lowell

**Government fiscal year(s) was this REU participant supported:** 2014

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**Leah Jones**

**Email:** jlj3ua@virginia.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** Yes, Chile - 0 years, 0 months, 7 days

**Year of schooling completed:** Junior

**Home Institution:** University of Virginia

**Government fiscal year(s) was this REU participant supported:** 2014

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**Hans Kulenkampff**

**Email:** hans.ks91@gmail.com

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Chilean REU student

**Funding Support:** Chilean

**International Collaboration:** Yes, Chile

**International Travel:** Yes, United States - 0 years, 2 months, 8 days

**Year of schooling completed:** Other

**Home Institution:** Univesity of Concepcion

**Government fiscal year(s) was this REU participant supported:** 2014

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**Zuleyka Marquez**

**Email:** zuleyka\_marquez@brown.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** Yes, Chile - 0 years, 0 months, 7 days

**Year of schooling completed:** Junior

**Home Institution:** Brown University

**Government fiscal year(s) was this REU participant supported:** 2014

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**Anna Moh**

**Email:** annapm@vt.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** Yes, Chile - 0 years, 0 months, 7 days

**Year of schooling completed:** Sophomore

**Home Institution:** Virginia Tech

**Government fiscal year(s) was this REU participant supported:** 2014

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**Adolfo Rodreguez**

**Email:** organic.o@hotmail.com

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** Yes, Chile - 0 years, 0 months, 7 days  
**Year of schooling completed:** Junior  
**Home Institution:** Universidad del Sagrado Corazon  
**Government fiscal year(s) was this REU participant supported:** 2014

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**Lina Rodriguez**

**Email:** lcrodrig@syr.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student on Exchange in Chile

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** Yes, Chile - 0 years, 2 months, 8 days  
**Year of schooling completed:** Junior  
**Home Institution:** Syracuse University  
**Government fiscal year(s) was this REU participant supported:** 2014

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**Jordan Sanders**

**Email:** Sand0494@vandals.uidaho.edu

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** Yes, Chile - 0 years, 2 months, 8 days  
**Year of schooling completed:** Other  
**Home Institution:** University of Idaho  
**Government fiscal year(s) was this REU participant supported:** 2014

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**Joel Strothers**

**Email:** Joelstrothers@gmail.com

**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** REU Student

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No  
**Year of schooling completed:** Junior  
**Home Institution:** Medgar Evers College  
**Government fiscal year(s) was this REU participant supported:** 2014

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**Luke Yarnall****Email:** lukebrianyarnall@email.arizona.edu**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 3**Contribution to the Project:** REU Student**Funding Support:** NSF**International Collaboration:** No**International Travel:** Yes, Chile - 0 years, 2 months, 8 days**Year of schooling completed:** Junior**Home Institution:** The University of Arizona**Government fiscal year(s) was this REU participant supported:** 2014**What other organizations have been involved as partners?**

Name	Type of Partner Organization	Location
Universidad de Concepcion	Academic Institution	Concepcion, Chile

**Full details of organizations that have been involved as partners:****Universidad de Concepcion****Organization Type:** Academic Institution**Organization Location:** Concepcion, Chile**Partner's Contribution to the Project:**

Financial support

Facilities

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:** University of Concepcion pays for two Chilean students to participate in the US. They also host and mentor two US students in Chile**Have other collaborators or contacts been involved? No****Impacts****What is the impact on the development of the principal discipline(s) of the project?**

Each participant research project made incremental contributions to the science and engineering in the area of sustainable forest bioproducts.

**What is the impact on other disciplines?**

The participant projects will not likely impact other disciplines directly, but will indirectly as products produce find broad use. In addition, the project impacted the teaching of STEM at the middle school level through dissemination by the RET participant.

**What is the impact on the development of human resources?**

All the participants become better trained in research methods and carrying out and writing up research. Many of the participants have expressed interest in pursuing a graduate education which is an important impact of the REU program goals.

**What is the impact on physical resources that form infrastructure?**

Not applicable

**What is the impact on institutional resources that form infrastructure?**

Not applicable

**What is the impact on information resources that form infrastructure?**

Not applicable

**What is the impact on technology transfer?**

The RET portion of the work is made available to the general public. Further, several projects resulted in potential intellectual property that may be licensed or spun out in the future

**What is the impact on society beyond science and technology?**

Any possible inventions that may result from the research performed would benefit the public in a positive manner especially the development of fuels or materials from forest-based resources. There is also the potential for the creation of new jobs from any commercial development.

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**Changes/Problems****Changes in approach and reason for change**

Nothing to report.

**Actual or Anticipated problems or delays and actions or plans to resolve them**

One REU student was identified by the University of Maine Information Technology Department as using university resources to illegally download copyrighted materials and illegally sharing them. The university determined that the student was legally liable, not the institution, and left it to the student to deal with the legal implications.

The same student arrived at the airport prior to the international field component of the program without a passport. This occurred despite repeated announcements of requirements for international travel and the fact that the individual did possess a passport. The individual found the passport later in the day, but elected, despite the PI's work to rebook flights, not to participate in the field component.

**Changes that have a significant impact on expenditures**

Nothing to report.

**Significant changes in use or care of human subjects**

Nothing to report.

**Significant changes in use or care of vertebrate animals**

Nothing to report.

**Significant changes in use or care of biohazards**

Nothing to report.

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**Special Requirements**

**Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.**

Nothing to report.