

BACKGROUND INFORMATION

Two genomic research projects to tackle supply and demand issues in emerging forestry biofuels industry

PROJECT TITLE

Optimizing Ethanol Fermentation From Mountain Pine Beetle Killed Lodgepole Pine

PROJECT DESCRIPTION

The development of alternative energy sources like wood-to-ethanol biorefining is an important step to improving environmental sustainability. British Columbia has extensive forestry resources and, more importantly, has a problem/opportunity with how to better utilize mountain pine beetle-killed lodgepole pine that will be increasing unusable for traditional lumber and pulp and paper applications..

The researchers will use the excess beetle-killed pine as a source of fermentable sugars and will use genomics to enhance enzymes, nature's catalysts, to increase the efficiency of liberating fermentable sugars from the pine.

In order to produce ethanol from the complex sugars in woods such as lodgepole pine, the trees must be pretreated using a variety of different methods and then the wood is enzymatically digested into fermentable sugars. One method to liberate fermentable sugars is to use naturally occurring fungi that can digest the complex lignocellulose sugar in the wood. The researchers will identify proteins (enzymes) that improve the breakdown of specific lignocellulosic feedstocks by analyzing the proteome of secreted proteins (enzymes) in wood-degrading fungi.

The social science and humanities (SSH) component of this work looks at the potential environmental and economic impacts of the research. Life cycle and techno-economic modeling will be employed using existing models and incorporate project parameters in order to allow modeling of the technical results of the current project. Existing data, gathered through a literature review, will be inputted into life cycle and techno-economic models to create experience curves describing the impact of technological change. The experience curves will be broken down to better understand the impacts of each process stage (pretreatment, enzymatic hydrolysis, and fermentation) as well as the production of by-products on the costs of generating biofuels using the bioconversion platform. The life cycle and techno-economic models will then be used to evaluate the impacts of research in terms of environmental or economic measures. Ultimately, this combination of environmental and economic data will describe a suite of optimal approaches to bioconversion of lignocellulosic feedstock for BC.

PROJECT LEADER BIOGRAPHY

Dr. Jack Saddler

Dr. Jack Saddler is Dean, Faculty of Forestry and Professor of the endowed Chair of Forest Products Biotechnology at the University of British Columbia. He is a fellow of the Royal Society of Canada, and the winner of several international awards such as the IUFRO Scientific Achievement Award, the Charles D. Scott Award for Scientific/Technical Contributions to

Biotechnology for the Production of Fuels and Chemicals, as well as receiving several other international recognitions.

His Ph.D. is from the University of Glasgow, Scotland (1978) and his BSc (Honours) from the University of Edinburgh, Scotland (1975). He is Task Leader for the International Energy Agencies (IEAs) liquid biofuels network. His research involves the study of microbial lignocellulosic materials (forestry and agricultural materials) for ethanol production.

He has published over 300 peer reviewed articles, has been awarded several patents, is a reviewer for several international funding agencies such as the US Dept of Energy and the EU, and works with multinational companies/associations (OECD, IEA etc.,) in the biorefinery/bioenergy/climate change areas.

ADDITIONAL INFORMATION

Project Value: \$1,153,604

Primary Project Funder: Genome British Columbia

Project Co-Funders: Novozymes Inc., NSERC

Involved Research Institution: University of British Columbia

Field of Activities: Biofuel, renewable energy, forestry

PROJECT TITLE

Optimized Populus Feedstocks and Novel Enzyme Systems for a British Columbia Bioenergy Sector

PROJECT DESCRIPTION

The human contribution to greenhouse gas emissions is a large factor in the recent global warming trends. Therefore, minimizing emissions is essential to sustaining the environment and reducing the rate of global warming. One of the major sources of greenhouse gas emissions is the use of petroleum products for fuel and there is an urgent need for bio-based alternatives including ethanol-derived fuels, as one part of greenhouse management strategies.

Poplar (black cottonwood, *P. trichocarpa*) is the first tree for which a complete genome sequence was determined, and the researchers aim to use this information and state of the art genomics tools to optimize breeding and selection of fast growing poplars (*P. trichocarpa*) to improve their potential as a biofuel resource.

Poplars and aspens are native to British Columbia, have inherently fast growth rates and wood that is easier to convert to fermentable sugars than conifers using current bioprocessing technologies. However, poplar wood is biochemically complex and more difficult than grains (like corn for example) to break down and liberate sugars for use in biofuel production. To facilitate rapid breeding of improved poplar varieties that have optimized biofuels and biomass traits, the researchers will perform genomic, phenotypic and genetic analyses to study natural poplar variants and will collaborate with US Department of Energy-funded scientists to identify gene variants that contribute to improved traits. To enhance the efficiency of solubilization of fermentable sugars from poplar wood, the researchers will also collaborate with American counterparts to find enzymes in wood-rotting fungi that will help liberate the sugars from the complex macromolecules in wood. Concurrently, this project will investigate the economic feasibility of establishing poplar plantations as a source of biofuels as well as the public perceptions surrounding biofuel plantations.

Public awareness of, and concern about, the influence of forest management practices on genetic variation of forests is growing. The focus of the social science and humanities (SSH) component of this research will therefore examine the social context of Canadian forest management policies that promote breeding and selection strategies for *P. trichocarpa* plantations for use in bioenergy by developing, delivering and analyzing a survey of British Columbians' attitudes toward the use of selectively bred poplar for bioenergy. It is anticipated that by understanding public attitudes toward the management of forest lands and genetic stocks, natural resource managers and planners may anticipate the public acceptability of certain management actions and identify areas that may require communication strategies to explain the rationale behind management actions. Combined with the analysis of the economic implications of large-scale selectively bred tree plantations, this research will develop policy options for the management of selectively bred trees for use in bioenergy production.

PROJECT LEADER BIOGRAPHIES

Dr. Carl Douglas

Dr. Carl Douglas is a professor at The University of British Columbia in the Department of Botany, where he began as an assistant professor in 1987. He earned his PhD at the University of Washington in 1983 working in the area of plant transformation by *Agrobacterium tumefaciens*. This was followed by postdoctoral fellow positions at the University of Washington and the Max Planck Institute for Plant Breeding Research in Cologne, Germany where he worked in the area of plant molecular biology and biochemistry. At UBC, he was promoted to associate and full professor, and served as Department Head from 1999 to 2006. He spent the 2001/02 academic year as a guest professor at the University of Agricultural Sciences in Vienna, Austria, and was a guest professor at the CNRS/Université Paul Sabatier, Toulouse, France in 2007.

Dr. Douglas' research interests are in the area of the control of plant gene expression, plant phenolic metabolism, plant cell walls, and plant and tree genomics. He was a co-Principal Investigator on the Genome Canada Competition I Forestry Genomics (Treenomix) project and was a major contributor to the sequencing of the poplar genome. His lab has used *Populus* (poplar) as a model tree species to study the regulation of wood development since 1988. He is currently working both on Arabidopsis and poplar as model systems to study the genetic regulation of secondary cell wall formation, the formation of the extremely durable pollen cell wall, and on methods to improve poplar and other trees as a potential crop for alternative energy sources.

He has invited to give recent lectures in the U.S., Japan, Germany, Spain, and Cuba. He currently teaches first year biology in the UBC Science One Program.

Dr. Shawn Mansfield

Dr. Shawn Mansfield is an associate professor at UBC in the Department of Wood Science in the Faculty of Forestry. He received his MSc in microbiology and immunology from Dalhousie University (1994) and PhD in forestry from UBC in forest products biotechnology (1997) working novel enzyme applications for wood and fibre development. Dr. Mansfield was a postdoctoral fellow at the Forest Science Research Institute of New Zealand from 1998-99 and concurrently held a visiting scholar position at the University of Waikato in the Department of Biological Sciences where he taught biochemistry. He is the current Canada Research Chair in Wood and Fibre Quality Research and is a Fellow of the International Academy of Wood Science.

Dr. Mansfield's research interests involve studying the biochemistry and genetics of forestry products including cellulose biosynthesis, biotechnological applications of enzymes in pulp and paper quality and the genetic relationship of gene expression and desirable phenotypic traits. He is currently a Project co-Leader with Dr. Carl Douglas on studying poplar as a potential source of biomass for alternative energy sources.

ADDITIONAL INFORMATION

Project Value: \$7,683,501

Primary Project Funder: Genome British Columbia

Project Co-Funders: US Department of Energy Bioenergy Sciences Center (Oak Ridge, TN); US Department of Agriculture Forest Products Laboratory (Madison, WI); Sveriges Lantbruksuniversitet (SLU) ENERGYPOPLAR (Umea, Sweden)
Involved Research Institutions: University of British Columbia, University of Victoria
Field of Activities: Biofuel development, forestry, alternative energy sources

For more information about Genome BC, visit www.genomebc.ca

-30-

Media contact:

Rachael Froese Zamperini
Communications Consultant, Genome BC
604.612.6345 or rzamperini@genomebc.ca