Socioeconomic Impacts of Wood-based Biofuels Development Strategies on Northern Rocky Mountain Communities in the Northwest

Introduction

Goals and Objectives

This project aims to support optimization of a regional-scale, liquid biofuel industry that benefits rural communities in the Northern Rocky Mountains of the northwest U.S., while meeting regional and national liquid biofuel production goals. Results will help guide the optimum economic use of the region's woody biomass and provide useful information for public and private decision-makers at the community, state and regional levels.

The project will evaluate the economic and social impacts of alternative bioenergy technologies and related development strategies at community, state and regional scales. The study area is the northern Rocky Mountain forests in Idaho, western Montana, and the forested areas of eastern Washington and Oregon adjacent to Idaho. To insure the analysis is realistically grounded in challenges and opportunities facing the region's rural communities, we will involve public and private stakeholders throughout the two-year project.

Specific Objectives

1. Model the regional bioenergy system to determine the overall viability and profitability of different bioenergy strategies for woody biomass utilization.
2. Using stakeholder input and technical knowledge, develop alternative scenarios for bioenergy development in the region and in the study area.
3. Determine the economic impacts of alternative scenarios of woody biomass and bioenergy production on communities in the study area and on state and regional economies. These analyses will be tailored to the study area's geographic and social-economic features with a focus on rural areas.
4. Integrate external stakeholder data, guidance and feedback to connect the project to local economic opportunities and constraints in the study area.
5. Disseminate study findings to external stakeholders for the purpose of helping local and regional organizations use the new information as they plan and implement economic development activities.

Substantiation of Project Need

The northwestern U.S. has great potential to develop a liquid biofuel industry, primarily because the region has abundant woody biomass resources that can be used as feedstock. As evidence of this potential, USDA NIFA recently awarded $40 million to the Northwest Advanced Renewables Alliance project (NARA) to support development of an aviation biofuel industry based on woody biomass feedstocks. A regional-scale aviation biofuel industry could provide both economic and environmental benefits to communities and businesses in the region.

One key to developing an economically viable liquid biofuel industry is the supply of affordable and reliable feedstocks. The Northwest has enough woody biomass to support a liquid fuel industry. However, some of these feedstocks are already being used for other purposes such as electricity or steam generation, some are unavailable for political reasons, and current input and product prices may not be such that the industry is economically viable. More feedstocks could become available under a different price structure since the supply available depends on the price for the biomass. As prices rise, the amount of biomass available increases dramatically: one study found in Idaho, for example, that 204,000 tons were available at less than $25/ton while 7,166,000 tons were available at <$55/ton (Nicholls, 2008). While enough biomass exists to support substantial bioenergy development, the issue is how much of the material can be economically recovered. Current market values for biomass generally will not pay for harvest, collection, size reduction, and transportation, except under the most favorable conditions (Nicholls, 2008).

Three approaches could potentially increase the available supply of biomass: (a) increase the value of biomass by increasing demand; (b) reduce the costs of collecting, aggregating and transporting biomass; and / or (c) subsidize this stage of production through federal and state policy. Using any one of these approaches will likely set off market dynamics that are poorly understood. For example, under the current price structure, using woody biomass for other purposes, such as gasification for electricity generation, is often not feasible because of the cost of securing feedstocks. If the cost of bringing biomass to market falls, however, these alternative uses would benefit alongside the aviation biofuel industry. Thus, alternative and competing uses might become more economically feasible than they are now. Similarly, a large-scale liquid biofuel industry could drive development of other bioenergy technologies, which would undoubtedly complicate the allocation of existing feedstocks to different uses. If increased prices for liquid fuels and electricity drive an increase in demand which then increases the value of the feedstock enough to offset production costs, this could free up more woody biomass and would likely impact existing industries that already use woody biomass feedstocks.

The benefits and tradeoffs of developing a regional liquid biofuels industry on existing industry uses of biomass in the study area need to be researched to optimize the use of this resource from a community, state and regional perspective. For example, Idaho and western Montana are not an empty playing field for biomass utilization, with 109 primary forest products plants in Idaho in 2001, including "35 sawmills, 22 post, pole and other roundwood product manufacturers, 17 plants utilizing mill residues to produce various products including pulp, paper, particleboard, landscaping bark, and electricity, 10 cedar products manufacturers and 4 plywood and veneer plants" (Morgan, et al., 2004). Idaho has one of the largest forest products industries relative to state economy. In 2001, timber-processing facilities operated in 28 of Idaho's 44 counties, and timber was harvested in 33 counties, with the greatest concentration of facilities in the 10 northern counties (Morgan, et al., 2004). In 2004, 215 facilities operated in 28 counties in Montana, with most facilities located near forests in the western portion of the state (Spoelma, Morgan, Dillon, Chase, Keegan, & DeBlander, 2008). Currently all mill residues are being used in state in Idaho and Montana. A developing liquid biofuels industry based on woody biomass needs to successfully integrate with other existing and future biomass uses, including the well established forest products industry in this region.

The study area includes all of Idaho, western Montana and the forested edge of Washington and Oregon. As a whole, this region has a land area of 153,338 square miles, a population of almost 2.9 million people and a PPM of 19. While the region grew by 16.8% between 2000 and 2010, 16 of its 75 counties lost population. The region's per capita personal income was $32,621 in 2009, and it had an annual average unemployment rate of 9.2% in 2010.

Like the region's forests, the region's economy does not follow state boundaries. Idaho, the only entire state in the study area, provides an example of how state boundaries do not mirror economic boundaries in this region, complicating economic analysis and requiring an approach at multiple scales. Idaho's economy is divided into three, integrated regional economic areas that spill into six surrounding states. The regional economic area for northern Idaho is centered in the Coeur d'Alene, Idaho-Spokane, Washington corridor, which includes northern Idaho, eastern Montana, and a portion of southern Canada. Boise, the state capital, is located in the center of the state and dominates the economic area of southwestern Idaho and includes eastern Oregon, a portion of northern Nevada, and western Utah. The economy of southeastern Idaho is centered in Salt Lake City, Utah. It includes the cities of Pocatello, Idaho Falls, and the regions of western Wyoming and southern Montana. Thus Idaho's political boundaries bear little relationship to its economic boundaries. Spokane, Washington; Boise, Idaho; and Salt Lake City, Utah all represent the "central place" of the economy of the surrounding communities.

Idaho also provides an example of the potential of bioenergy development to support much needed economic development in this area. Idaho is a relatively large state, ranking 11^{th} in the U.S. in land area (82,643 square miles). With 1.5 million people, it also has one of the smallest populations in the country, ranking 39^{th} in 2010. The state's large area and small population mean that, on average, there are only 19 people per square mile (PPM) in 2010. This is quite low compared to an average 87 PPM in the U.S. and 839 PPM in Massachusetts (State and County QuickFacts). Between 2000 and 2010, Idaho ranked 4^{th} in the nation in cumulative population growth, with a 21.1% increase. While Idaho contains some of the fastest growing regions in the country, some of its most rural counties are losing population, due almost entirely to shrinking employment in natural resource industries. The steepest population declines and highest unemployment rates have occurred in counties that historically had vibrant timber industries. In contrast, most population growth has taken place in urban areas, particularly the Boise City-Nampa metropolitan statistical regions (MSA) and the Coeur d'Alene MSA. Two-thirds of the state's population now lives in metropolitan counties (American FactFinder). Per capita personal income in the state ($31,857 in 2009) is very low (ranking 48^{th} in the nation) (Regional Economic Accounts).

A viable, market-based bioenergy industry could significantly increase income and job opportunities in rural parts of the Northern Rocky Mountains. Idaho County, for example, is centrally located in the region and typical of counties that stand to benefit from a viable industry. The local economy relies heavily on timber and wood products, which have been hit hard by the recent recession, and on agriculture to a lesser extent. Unemployment rates in Idaho County are consistently higher than in the state and the U.S. Over four-fifths of the county's land area is federally owned, mostly as national forest lands. The county has poorly developed transportation systems and infrastructure in general. With almost 8,500 square miles, it is larger than 6 U.S. states (State and County QuickFacts). From 2000—2010, Idaho County's sparsely settled population grew by less than 5% (American FactFinder). In 2009, its per capita personal income was only $27,506, compared to $31,857 in the state as a whole, and $39,635 in the U.S (Regional Economic Accounts).

Although a flurry of bioenergy feasibility work has occurred in the Northern Rocky Mountain region over the last decade, little to none of this work has accounted for the effects of developing a regional biofuel industry. Many counties and some cities have developed feasibility studies for gasification plants to generate steam and electricity, of which five studies are public—Adams, Clark, Gem, Boise and one for the city of Sandpoint in N. Idaho (Adams County, 2010); (Department of Forest Products, 2002); (McKinstry, 2011); (Biomass Energy Resource Center, 2010) (Whisper Mountain Professional Services, Inc, 2010). These studies varied in their conclusion of feasibility, but all identified 3 similar factors: the lack of reliable supply, short haul radiuses for feedstocks before it becomes cost prohibitive and that it costs more to harvest biomass in many areas than its value as an energy feedstock. These factors determine the available feedstock for a regional system, and whether the supply is sufficient to support the more intensive local needs of a gasification plant. For example, a 2011 study of Boise County found insufficient feedstock supply within a 120 minute transport time to meet investment grade criteria for funding to site either a 10-20 MW or a 3MW facility in the county (McKinstry, 2011). Clark County found insufficient supply within a 100 mile radius, Adams found 53 miles as the breakeven point for collecting, aggregating and transporting woody biomass from forest thinning and logging residues. Out of the five public feasibility studies, Clark, Gem and Boise counties found insufficient and unreliable supply as obstacles to the feasibility of bioenergy facilities. Adams County and Sandpoint did not find supply availability to be a problem, (Adams County, 2010); (Biomass Energy Resource Center, 2010).

This project addresses information needs at multiple levels. Specifically, if the liquid biofuels industry is to benefit rural communities while meeting regional and national production goals, the development strategy must rely on integrated data and analysis, as well as the identified needs and resources of communities and states in the Northern Rocky Mountains. A unique feature of this project is in-depth stakeholder participation in the process of identifying obstacles and opportunities for woody biomass bioenergy development. At the same time, data and analysis of benefits and tradeoffs, and likely impacts on biomass supply and markets need to be integrated into local, county, state, and regional economic development strategies for this resource. By addressing both of these information needs, this project will supply the data and analysis to optimize the integration of Northern Rocky Mountain forest biomass into a liquid biofuels industry so that national goals for liquid biofuels production are met while maximizing benefits to communities in the region.

Ongoing Work Relevant to the Project

Darin Saul is currently working on two funded projects relevant to this proposal. He directs an EPA funded project to implement a social market approach to minimizing waste and increasing recycling. This includes conducting surveys, interviews, and focus groups to determine a population's understandings, attitudes and beliefs about an issue area. This data is used to guide a communications strategy that is piloted with focus groups of stakeholders, refined and then launched at a much larger scale. He is also currently directing an AFRI Foundational Program Increasing the Prosperity of Small and Medium Sized Producers grant to determine the feasibility of developing small scale USDA-certified livestock processing infrastructure. His portion of the project includes collaboration on surveys, individual and group interviews, development of case studies, and quarterly stakeholder planning and discussion forums. From 1998-2005 he directed subbasin planning efforts in most of the Snake River subbasin as part of the Northwest Power and Conservation Planning Councils Subbasin Planning Effort. This included running 46 public involvement meetings, and organizing and coordinating stakeholder and technical advisory groups in eleven Subbasins in the Snake River including the Clearwater, Salmon, Boise, Payette, Weiser, Owyhee, Bruneau, Hells Canyon, and the two Middle Snake subbasins in Idaho, and the Imnaha Subbasin in Oregon. He also directed writing some or all of the assessments, inventories and plans written for each of these subbasins as part of the program.

Over the last seven years, Priscilla Salant and Debbie Gray directed Idaho Horizons, a foundation-supported program to build local leadership capacity and reduce rural poverty in seven states, including Idaho, Washington and Montana. Through the 18-month Horizons program, the University of Idaho developed on-going relationships with the 49 small Idaho towns that participated and whose leaders are now mobilized to improve economic prosperity and think regionally. These relationships are the basis for university / community partnerships involving engaged student learning and research, such as the project proposed here. More than two-thirds of Idaho's Horizons communities are located in the timbered parts of the state. They include a significant number that have historically relied on timber and wood products industries for their economic livelihood. The stakeholder involvement component of the proposed project will greatly benefit from the university's relationships with these communities, coupled with the communities' strong leadership and clear social and economic priorities.

Stephen Devadoss has worked on topics related to biofuel policies. He has guided thesis research related to the impacts of biofuel policies, and has published papers in this area. He also teaches undergraduate and graduate level courses in policy analysis.

Scott Metlen participated in a project to develop a best location evaluation, looking at the tools necessary to determine an optimal location for a biodiesel production facility based on location of feedstock, labor, knowledge, community structure, and transportation choices, which resulted in a recent publication (Metlen, 2008). Another project to determine the cost of chipping logging slash once it is near a road in Northern Idaho looked at equipment and labor needs to chip and haul chips from logging slash once it is on or near a logging road. The pertinent data is the cost of chipping and hauling based on site and density. This work is currently being prepared for submission for publication (Morris, O'Laughlin, Gorman, & Metlen).

Rationale and Significance

Woody biomass is an important potential feedstock for liquid biofuels. Although abundant woody biomass resources exist in the Northern Rocky Mountain forests of the northwest U.S. to feed into a regional liquid biofuel industry, large portions of this resource are currently unavailable for bioenergy production because of a lack of economic viability in its use. In addition, the area has a well developed forest industry, and other existing and potential uses of the woody biomass feedstocks to complicate development of a reliable regional feedstock supply. Any major new use of biomass feedstock will likely effect existing industry either through increasing demand and prices for biomass or decreasing cost of bringing biomass to market through technological innovation or subsidy.

Because of the importance of the existing forest industry in the Northern Rocky Mountains, and the low income levels and economic challenges faced by communities in the area, particular attention needs to be paid to optimizing biofuels development strategies to maximize benefits to rural communities. The feasibility, benefits and tradeoffs of different technology pathways need to be better understood at local, state, and regional levels. Furthermore, to be successful, a regional system will need to adapt to the complex local circumstances important to the feasibility of a reliable supply, drawing an optimal amount of feedstock from the area without causing more disruption than benefit to affected communities.

In addition to economic analysis, stakeholder data and engagement are important to ground the project in actual on-the-ground constraints and opportunities, as understood by those living and working in the study area, and to increase the value of the project to the elected officials, economic development professionals, and other key stakeholders from the area critical to successful bioenergy development. The many planning efforts and feasibility studies for bioenergy development in the U.S. Northern Rocky Mountains also need to integrate the needs and benefits of a regional liquid biofuel industry into their feasibility processes.

This project will provide the analysis and the stakeholder research and engagement to bridge these two levels of activity: regional level research and planning and more local bioenergy feasibility activities. Involving stakeholders in the interpretation of results also will help broaden both the validity and the usefulness of project analyses and results.

In addition to providing publications and presentations to provide data and analysis to broader regional and national efforts, this project will provide results that feed directly into ongoing bioenergy planning and development efforts at state, regional and federal levels.

The study area includes Idaho and western Montana, and the forested eastern edges of Oregon and Washington adjacent to Idaho. This area was chosen for analysis because of its economic and ecological coherence and differences relative to the rest of the northwestern U.S.

Relationship to Program Area Priorities

This project addresses goals of the "Socioeconomic Impacts of Biofuels on Rural Communities" program area of the Sustainable Bioenergy AFRI Challenge area. This project will enhance scientific knowledge of the impacts of different bioenergy technologies and systems at county, state and regional scales to identify direct and indirect benefits and tradeoffs. The project will optimize the mix of technologies and feedstock uses in state bioenergy and regional biofuel production systems. This project will also integrate engaged scholarship with rural communities in Idaho to identify knowledge, attitudes, and needs of community and county development professionals, policy makers, industry and key community stakeholders critical to their participation in and support for bioenergy development efforts. These project analyses will support the Sustainable Bioenergy Challenge Area research programs for the development of liquid transportation biofuels to meet Energy Independence and Security Act goals and Renewable Fuel Standards mandates.

Relationship to AFRI Specific Goals

The project directly addresses the AFRI goal of securing America's energy future. It also addresses the Sustainable Bioenergy Program more specific goal of reducing the National dependence on foreign oil through the production of sustainable bioenergy. The project addresses these goals by supporting the development of a liquid biofuels industry from woody biomass feedstocks in the Northwest. Furthermore, the project meets other AFRI goals to enhance environmental quality and the natural resource base by improving forest health, reducing air pollution by burning biomass in a controlled environment rather than in the open forests, and reducing a human-caused problem of excessive build up of fuels in northwest forests, helping forests return to a more healthy fire regime. Development of a liquid biofuels industry has the potential to address the AFRI goals of increased economic viability of agricultural communities throughout the Northwest by stimulating demand for biomass and increasing jobs extracting, transporting and processing the feedstock. Development of biofuels and other bioenergy industries will also help meeting the AFRI goal to mitigate and adapt to climate change by displacing fossil fuel based energy production through advancement of a renewable energy industry.

The project also furthers the National Research Council Committee goals to contribute to biofuel needs, to enhance environmental quality and the natural resource base, and to sustain the economic viability of agriculture. This project develops research to advance the biofuel industry, which will enhance forest health and air quality, and increase the economic viability of communities in forested areas of the region.

Approach
This project will develop plausible scenarios for regional biofuel development under a range of demand and supply side drivers for woody biomass. Investigators will collect data and model the costs and benefits of each scenario. Socioeconomic impacts of these scenarios will be modeled for the Northern Rocky Mountain feedstock areas including Idaho, Montana, and the forested eastern portions of Washington and Oregon adjacent and contiguous to Idaho.

A key component of this project is to engage key stakeholders to help investigators understand the economic, political, and social context for the proposed industry; design realistic scenarios that take these contextual variables into account; and interpret study results and their implications. Stakeholder engagement will be accomplished through three means: interviews with individual and group stakeholders, a stakeholders communication forum and the use of a project advisory committee consisting of local and state elected officials, economic development professionals, policy makers, industry representatives and other key stakeholders. The advisory committee will also include NARA project PIs, to ensure compatibility and avoid duplicating NARA project efforts (see letter of support).

Proposed Activities
<u>Discreet simulation and mathematical modeling approach</u>
Utilizing discreet event simulation and mathematical modeling techniques, we will develop effective system pathways of each technology from source to point of sale, determining boundaries where benefits and impacts move outside of the study area, and will model the number of jobs created and other benefits within study area. This includes modeling transportation differences between technologies, including distances to refinery locations. This portion of the project will also develop a model to determine the overall viability and profitability of bioenergy strategies for woody biomass from the community perspective. Outputs from this portion of the project will include:

1. Primary data dealing with costs and resource needs to deliver thinning and slash to roadside for chipping.
2. Simulation models to determine resource needs and total costs based on those needs to harvest and produce the end product. The end product will be dependent upon the transformation process used.

3. Transformation facility or tool location modeling based on various modeling tools. Outcomes will be resource needs so community impact can be calculated and location considerations to also determine community impact.

Regional Optimization Modeling
A nonlinear optimization model will be used to assess the feasibility of options for feedstock and biofuels production, including evaluation of different production technologies, and under a variety of scenarios for different fuel product pricing and levels of production subsidies. The analysis will determine which technological pathway will produce bioenergy for the least cost and most profitability.

Economic Impacts Research Approach
Utilizing county and state input/output methodologies, we will organize the study area into sub-regions, and we will evaluate the economic impacts and contributions of each technology for each sub-region under analysis, including an examination of the backward economic linkages of each technology and a comparison of the appropriateness of each production method. This will include the following analyses:

a. Identify potential sub-regions of bio-energy collection (harvest), production, and distribution
b. Develop a base assessment to identify and report the actual drivers of the regional economy.
c. Use a social accounting matrix (SAM) input/output model to examine distributional effects of biofuels on income.
d. Use the input/output model to forecast the potential future effects on local economies from biofuel development.

Stakeholder research and involvement:
This project will engage key stakeholders to help investigators understand the economic and political context for the proposed industry; design realistic scenarios that take these contextual variables into account; and interpret study results and their implications. Stakeholder engagement will be accomplished through three means: stakeholder interviews, development of a stakeholder communications forum, and the use of a project advisory committee consisting of local and state elected officials, economic development professionals, industry representatives and other key stakeholders. The advisory committee will also include NARA project PIs, to ensure compatibility and avoid duplicating NARA project efforts.

Year one activities focus on collecting data, information and input from stakeholders. Stakeholder interviews will provide data and advisory committee activities will provide guidance, feedback and data for the development of scenarios. A communication forum through email and a website will be developed and used throughout the project.

Year two will involve stakeholders in interpreting study results. Meetings in communities in the study area will present project findings and involve stakeholders in interpreting results and to identify next steps in the feasibility process from stakeholder perspectives. Additonal stakeholder engagement with project activities and results will occur through the advisory board and stakeholders communication forum.

Research Methods

To achieve its goals and objectives, this study will address a series of interconnected and supplemental research questions through its various methods:

1. How does biofuel development fit in the Northern Rocky Mountains unique geography and economy? Which production technologies and related supply configuration would have the greatest economic development potential from a regional and national perspective?
2. What are benefits and tradeoffs of different bioenergy development scenarios in the study area? How will the benefits and tradeoffs be distributed among communities in the study area?
3. Are perspectives from different scales—national, regional and community--consistent and if not, can they be reconciled?
4. What are the distributional effects on incomes from biofuel development?
5. Are there other high value uses of this feedstock that could benefit if lower cost biomass production and transportation was developed? Are there other value-added processing and production operations which would benefit from development of regional aviation biofuels industry?
6. How will demand created by the development of a liquid biofuel industry impact woody biomass value? Will it push the value of the commodity above the cost of bringing it to market? If the value increases above the cost of bringing it to market, how will this impact the industries already established in the study area that use woody biomass?
7. What is the optimal amount of woody biomass feedstock that can feed into a regional liquid biofuel industry that optimizes benefits for the study area?
8. How will development of a regional liquid biofuel industry benefit and impact rural communities in the study area?
9. What do people in rural communities understand about bioenergy development options and what are their self-expressed information needs? What do they want to know?
10. What do people in rural communities think about the different scenarios and associated benefits and tradeoffs? What do they see as the opportunities and obstacles?

To answer these questions, the Investigators will work on four areas of activity: 1) discreet event simulation and mathematical modeling, 2) regional optimization modeling, 3) economic impacts, and 4) stakeholder research and involvement.

<u>Discreet event simulation and mathematical modeling techniques</u>,

To determine community, state and regional impacts of various biomass to power businesses, the number and types of primary and secondary jobs must be determined. To determine the number of total jobs it takes to move woody biomass to roadside and beyond, whether as wood, pellets, or liquid, the method of removal and treatment has to be determined. Work by Skog et.al. (2006) determined costs using traditional removal techniques. They did not look at nontraditional removal methods or go into detail such as the man-hours required and equipment needed. In this study we will look at nontraditional methods of woody biomass removal and transportation as well as traditional methods, and will also go into man-hour requirements and the equipment needed to help determine community impact. Knowing if the end product is wood chips, crude oil, or some intermediate state will help determine the cost of moving the raw product to a location where it will be transformed into power or concentrated into a denser fuel to be transferred into power later. Thus, different models will have to be created to address each proposed use of the biomass.

Data about what biomass is available and its location comes from such reports as Skog, et al. and other forest inventory models (Skog, et al., 2006). This data also contains other variables necessary for modeling such as slope, stand density, and distances. What the data does not contain are the details of non-traditional removal techniques. These techniques will have to be performed as time and cost trials over the course of two summers. The University of Idaho forests as well as private land will provide trial plots to test several removal techniques. These data, in conjunction with previous work by Morris (2009) and Skog (2006), will provide the basis for simulating costs and manpower requirements of the removal, grinding, and transportation of wood chips. Additional data from work done by Idaho National Laboratory will be used to determine on site conversion from chips to pellets through torrefaction and pelletization or to crude oil through pyrolysis.

To collect the new data, forest plots will have to be thinned and the thinning then transported to roadside. Plots that have been thinned will also be useful for experimentation. However, the actual act of thinning will have to be evaluated to determine man-hour requirements. Transportation devices that will be evaluated include cable logging with slings for small diameter and traditional log moving for logs. These slings will be filled by hand or by a person operating a miniature loader that has the capability of operating on steep, uneven ground. Specialized cable systems may have to be designed and the traditional systems modified to fit these designs for the cable system. Design and modification may also have to be carried out on a medium sized skid steerer.

Once data is available, discreet event simulation will be utilized to determine resources needed to produce different commodities at different rates of production at different sites. Resources include people and machinery such as grinders, pelletizers, trucks of different types, logging equipment, and machines that can either torrefy or conduct pyrolysis. Commodities would include chips for electrical generation or for oil derived fuels. These simulations will also provide cost ranges and probabilities that optimization techniques do not provide. Community impact can then be determined using this information in conjunction with expected impact on the cost and use of current woody biomass. The results from these endeavors will then be triangulated against the results from the regional optimization models discussed in the next section to help ensure accuracy.

Site selection will be determined by what commodity is chosen and through mathematical and logical modeling to determine the best location for a given commodity. These models will not only look at the least cost solution but will also take into account the impact on different communities where facilities are located. Community impact will be determined by the models depicted in the following section.

Regional Optimization Modeling

A nonlinear optimization model will be developed to maximize the profits of bioenergy production systems. Nonlinear optimization models are commonly used in agricultural economics for determining optimal productions and input use in crop, livestock, and dairy sectors. These models use the costs of production and enterprise budget data.

We will apply the optimization models to feedstock and bioenergy systems. Several economic parameters such as bioenergy policy variables, costs associated with production and distribution systems, input and output prices, biofuel demand, and technological information determine the viability and economic feasibility of various feedstock and biofuel options. The results of the other portions of the project will be synthesized to generate a cumulative report which will be used to develop the optimization model to assess the feasible and non-feasible options for feedstock and biofuel production and marketing. We will take into account various logistics and constraints in rural areas to optimally determine bioenergy production.

The model also incorporates different production technologies, including combustion, gasification, pyrolysis, and biosynthesis. The technological information such as the input/output conversion will be collected from the bioenergy processing plants and will be included as well the byproducts from the production system and their respective output prices. This analysis will determine which technology is best suited to produce bioenergy with the least cost combination.

This model will maximize profits of various bioenergy production systems and yield optimal levels of feedstock needed for production, other input (labor, machinery, energy) uses, bioenergy output, revenues, and costs. The model will also determine the biofuel prices needed for feedstock that can be viably supplied. The General Algebraic Modeling System (GAMS) will be used to solve the optimization model.

Economic Impacts Research Approach

This project will develop a Pacific Northwest model, a model of the main economic sub-regions within the study area, and county/sub-county economic models for the study area. The project will

1. Create an economic base assessment of the regional economy which identifies causal factors of economic growth. The goal will be to identify the causal factors of economic growth in the broad regional economies and the local rural economies.
2. Create detailed profiles of each region that include the economic, social, demographic, and historical trends. Included in these analyses are the human resources, capital infrastructure, transportation, and other resources needed for biofuel development.
3. Examine the interrelationships between the wood products industry and the biofuel industry to examine any potential synergies.
4. Develop a social accounting matrix (SAM) model using IMPLAN (Impacts for Planning) to assess the contributions of different sectors in the economy. The economic base will be calculated using the ASAM model developed by Rodriguez, Watson, and Braak (2010).
5. Build a series of economic IMPLAN input/output models tailored for each stage of production: every region of potential harvest (collection), each alternative technology and production method to be employed, each system of distribution.

An economic profile of the regional economy reflects the actual sales, value-added, wages, jobs, unemployment, income distribution, and other measures of economic activity in each sector of the economy. This profile will also include other social, cultural, and demographic trends.

Profile measures of economic activity are widely reported and used by policy makers and the public. While being very useful they do not identify the causal factors that drive an economy. These factors include exports (i.e. any activities that bring new money to the region) and the backward linkages that create the multiplier effects. The larger the magnitude of the multipliers, the greater the interdependency among the industrial sectors, resulting in less leakages through imports and savings.

Stakeholder Research and Involvement Methods

As noted above, the University of Idaho has on-going relationships with many rural communities in the state, including the 49 small towns participated in the Horizons program. The stakeholder research and involvement portion of the project will leverage these relationships to engage county and state elected officials, economic development professionals, and industry representatives in Idaho Horizons and other timber-reliant communities. Where practical, we will also work through colleagues at Montana State University and Washington State University to engage stakeholders from those states, which also had Horizons programs.
Specific activities include the following.

1. At the beginning of the project, we will form an advisory committee comprised of key external stakeholders from rural communities throughout the region. The purpose of the committee is to provide in-depth input into the project, scenario development, interpreting results and planning next steps.
2. In Year 1 of the project, individual in-person and phone interviews and in-person group interviews will be used to involve a broader group of local stakeholders in identifying local trends and characteristics that shape the context for the liquid biofuels industry. Stakeholder guidance and feedback will also be used in Year 1 to develop the alternative scenarios that will be analyzed through optimization modeling and economic impact analysis.
3. In Year 2, we will again conduct individual and group interviews to involve stakeholders in interpreting the results of the analyses and determining next steps in the feasibility process.
4. To supplement individual and group interviews in Years 1 and 2, we will use email and a website to create a stakeholder communication forum. The forum will be used to discuss challenges and opportunities in communities, interpret results of the analysis, and understand implications for development strategies.
5. Stakeholder networks developed through the advisory committee, interview process, and communication forum will be used to disseminate and use results among a widely dispersed rural stakeholder community.

All interviews and meetings will be documented. Resulting data will be synthesized, themed and organized to answer research questions and guide project analyses.

These methods are highly feasible. All researchers are experienced in the proposed methods and experienced with the study area. Stakeholder engagement at levels described in this proposal are also very feasible, building on seven years of work with 49 rural communities in Idaho.

Expected Outcomes

1) Provide a comparative analysis as a decision making resource about which technologies and development pathways to pursue.
2) Provide a model for understanding bioenergy development from community, county, state and regional perspectives.
3) Determine the optimal feedstock, drop in biofuels, employment, prices of all inputs, and supply and demand for biofuels under alternative prices. These results will determine the optimal use of woody biomass from Idaho, western Montana, and eastern forested areas of Washington and Oregon adjacent to Idaho, to produce bioenergy in the study area.
4) Enable the planning and feasibility work for bioenergy development that accounts for and integrates community perspectives, needs and resources.

Use of Results

Using the results of the modeling, analyses, and stakeholder data, the project PIs will develop a preliminary synthesis analysis that addresses a framework of research questions. The stakeholder advisory board will be engaged in reviewing and interpreting results and in formulation and interpretation of the synthesis analysis. The results will be written up into reports and publications and diseminated through the communications forum and websites, in addition to peer reviewed journals.

Project results will be used by NARA and other regional efforts to provide data and analysis necessary for development of a regional liquid biofuels industry. The project will provide in depth economic analyses for use in optimization and impacts work, and will provide integration of stakeholder data and engagement that will help regional efforts optimize use of Northern Rocky Mountain woody biomass feedstocks for liquid biofuel production while maximizing benefits to rural communities.

The project results will also be used to provide resources to local bioenergy feasibility work and efforts within the study area by integrating a regional liquid biofuel industry into modeling and analysis that to date has largely focused on the siting of biomass to electricity facilities.

Project results will also be useful as a model of integration of stakeholder data and engagement in economic modeling and analysis. Documentation and evaluation of this model will be included as part of project publications.

Potential Pitfalls

The project has a short timeframe for a project this complex. But if the project is to produce results in time to be a resource for the NARA project and feasibility work in the study area then it needs to proceed rapidly. All three economic analyses need to be completed on time to enable a synthesis and interpretation of results that includes meaningful involvement by stakeholders.

Limitations to Proposed Procedures

Model validation is only conceptual, as there is no current system to check it against. However, triangulation across several methodologies will help to ensure accuracy.

Hazardous Activities

No Hazardous activities are planned as part of this project.

Timeline