WESTERN MONTANA CORRIDOR

Sustainability
Volume IV

Northwest Advanced Renewables Alliance

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4 SUSTAINABILITY ANALYSIS

4.0.1 Introduction

The USDA NIFA AFRI CAPs in Sustainable Bioenergy are charged to:

> facilitate the establishment of regional systems for the sustainable production of bioenergy and biobased products that: contribute significantly to reducing the National dependence on foreign oil; have net positive social, environmental, and rural economic impacts; and are integrated with existing agricultural systems (USDA NIFA 2010).

Within this charge, the term “sustainable” applies not only for production, but also to the environmental, social and economic conditions that accompany an emerging industry using forest residuals to produce biofuels and co-products. Introduced in this volume are assessments that address the sustainability of this emerging industry. These assessments are preliminary and present the reader with a snapshot of their development based on the information obtained through 2013 in the WMC. As NARA ‘s work continues, these assessments will be updated. Fully developed assessments for the entire NARA region will be available in 2016 when the NARA project is complete.

Listed below are the four chapters available in this volume:

- Techno-Economic Analysis (TEA): The TEA provides an assessment for the overall economics of biofuels production from feedstock delivered to the mill gate through to biojet sale. The Tea models the capital requirement plus the fixed and variable operating costs for producing biojet from forest residuals.

- Life Cycle Assessment (LCA): The LCA assesses the environmental impact of producing aviation biofuels and compares it to the petroleum products for which it will substitute. This assessment considers options associated with various harvesting and production steps suitable for specific regions in the Pacific Northwest.

- Community Impact Analysis (CIA): The CIA utilizes economic models to measure the economic impacts on local communities from residual harvest activity, transportation, collection and storage of woody biomass materials, and processing into biojet fuels. Social accounting matrices will be constructed for counties in the WMC region and used to calculate multipliers that relate total dollars of input per dollar of output and the number of wage and salary employees per dollar of output.

- Education and Outreach: The NARA Education a Outreach Teams conducts surveys used to gauge community attitudes and knowledge regarding and emerging industry that uses forest residuals to generate chemical products like bio-jet fuel. Preliminary survey results and a summary of education activities are provided.

4.1 TECHNO-ECONOMIC ANALYSIS (TEA)

4.1.1 Approach

The NARA Executive Team directed establishment of a TEA founded on the National Renewable Energy Laboratory (NREL) analysis of producing celluloic-based ethanol. (Humbird et al 2011) Our analysis therefore utilized the analytical framework of the NREL effort while revising capital expenditures, operational expenditures, and fixed costs as appropriate. As such, our analysis used revised data for feedstock handling, pretreatment, and alcohol-to-jet operations. NARA corporate members Weyerhaeuser, Catchlight Energy, TSI, and Gevo provided the relevant cost and yield data for these operations.

Several scenarios were developed for operating the plant. For purposes of brevity, this summary will focus on the "Burn Lignin" scenario that includes:

- Feedstock Preparation and Storage
- Calcium Bisulfite Pretreatment
- On-Site Enzyme Production
- Standard Gevo Isobutanol (IBA) and Iso-Paraffinic Kerosene (IPK) Production
- Multi-Fuel Boiler Burning all Production Residues with Natural Gas for Energy Balance

Assumptions in this analysis and production scenario are as follows:

- Integrated Biorefinery – 770,000 BDT/yr
- Feedstock - ground slash piles – composition from NARA FS-10
- Greenfield Capital Expenditure (CapEx) Entire Facility
- Commercial Feedstock Costs of $68/BDT delivered to mill gate
- Burn Lignin and Screen Rejects

A more detailed development of this analysis is provided in Task SM-TEA-1: Techno-Economics Analysis of the 2013 NARA Cumulative Report (http://nararenewables.org/2013-report/).

4.1.2 Summary of Findings

Assuming a complete greenfield construction of an integrated biorefinery, and a 20% internal rate of return, the current cost estimate for producing biojet (IPK) from forest residuals will be 2 to 3 times the current spot market cost of petroleum jet fuel (Figure 3.1.1). With optimistic estimates for improved yields throughout the greenfield operation of the process, this value might be lowered to 1.45 times the cost of the petroleum equivalent. Whereas a greenfield operation of the current process is not projected to reach cost equivalence as is, the analysis aids NARA in focusing our work on programmatic efforts that may bring us to cost parity within our current time-frame using different strategies than our initial model. It should be noted that this initial model is a "worst case" scenario for costs and does not investigate many of the production scenarios currently under investigation.

Figure 4.1.1 shows a summary of the current status of the techno-economic analysis for an integrated biorefinery producing biojet (IPK) using forest residuals as a feedstock and assuming a complete greenfield construction. Relative contributions of individual cost centers are provided for the capital expenditures (CapEx) and operational expenditures (OpEx).

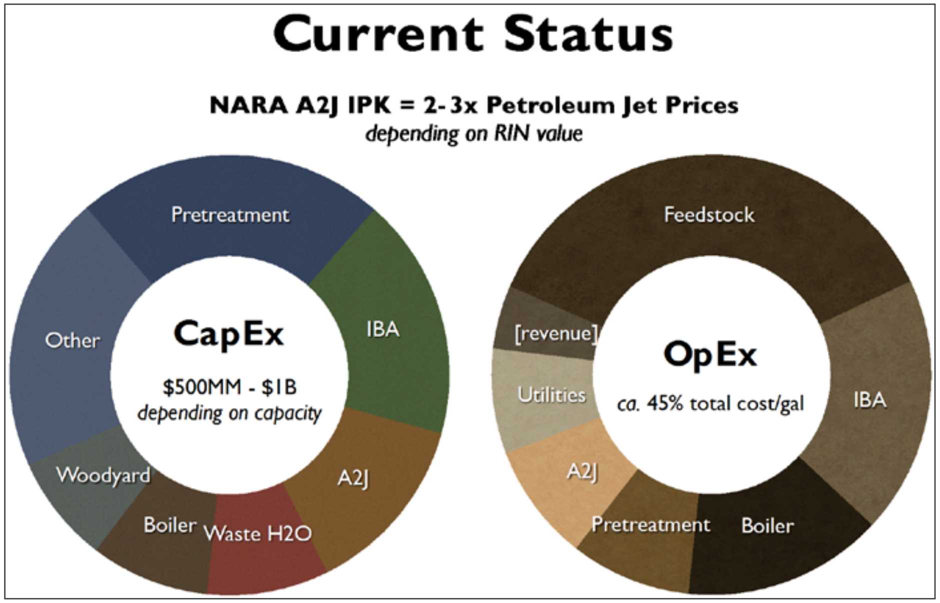

Figure 4.1.1 Current status of the techno-economic analysis

Interpretation of the analysis presents several highlights concerning the economic production of advanced biofuels:

1. A high CapEx for a greenfield construction of an integrated biorefinery will likely impose financing barriers for large plants.
2. The role of feedstock costs in the OpEx is critical. Even at relatively low mill gate costs for forest residuals, its role is dominant over every other cost center in the analysis.
3. Federal renewable fuel policies that influence financial incentives for production are crucial to successfully establishing an industry. In our analysis, these incentives are considered through the valuation of cellulosic and advanced biofuel RINs.

Carefully considering the three points above provides us with the opportunity to strategically position the current research efforts to reach an improved cost position within the project lifespan of NARA. The approaches will be discussed separately below.

Reducing the capital cost of a biorefinery is necessary to reduce production costs as well as to improve the access to capital for producers. The high capital costs of biorefineries are an issue that is not exclusive to NARA (Table 4.1.1). Of the ten commercial cellulosic biofuels projects currently under construction (Brown and Brown 2013), the average CapEx is $10.22 per gallon of annual capacity. (Lane 2013a) This figure is on the upper range of a previously reported estimate of $6-12 per gallon of annual capacity. (Lane 2013b)

Our estimate of CapEx per rated gallon of annual capacity for the NARA integrated biorefinery is similar to these values when viewed on an equivalent ethanol basis. By removing the Alcohol-to-Jet conversion process, the NARA CapEx would be less than $20 per gallon capacity isobutanol. This value can then be converted to an equivalent ethanol production by equating energy density of the alcohols (ethanol/butanol = 0.67), resulting in a NARA CapEx at ca. $13 per gallon of equivalent ethanol capacity. However, the additional process of converting to biojet drives the CapEx figure to more than $27 per gallon of capacity IPK. This increase can be accounted for in part, but not entirely, through the increased energy density. The additional CapEx involved in the step to convert alcohol to jet fuel would be similar for all such conversion processes, irrespective of the alcohol used.

Regardless of the exact measure, the capital requirements for building a biorefinery to produce biojet will be expensive. Reducing this CapEx requirement will, in the short term, facilitate developing the industry by both reducing costs and increasing access to capital.

Lane (2013a) delineates several financial and technology strategies for reducing CapEx requirements. One of these, retrofit of existing assets, has been a basic tenant of both NARA and its biofuels partner Gevo. Existing infrastructure that has potential for retrofitting to the NARA process includes the following:

- Existing or Dormant Pulp Mills feedstock preparation, pretreatment vessels, wastewater treatment, energy plant, rail transportation
- Existing or Dormant Ethanol Plants hydrolysis and fermentation vessels, tank farms, fuels distribution
- Petroleum Refineries chemical processes for alcohol to jet conversion

The assessment of existing regional assets to be applied to the emerging biofuels industry in pilot supply chains is a key component of NARA's goal to establish supply chain coalitions, and it is conducted by our Outreach and Education Teams. Illustrative case studies of how to retrofit existing assets for depot sites and conversion facilities in the WMC are provided in the WMC/Volume 3: Site Selection and Supply Chain Analysis.

Table 4.1.1. shows a summary of commercial cellulosic biofuels projects currently under development. Rated capacity, announced capital expenditure (CapEx) and cost per gallon of annual capacity are provided for each projects. Data is provided to compare to the NARA TEA estimates in this project report.

For instance, our initial pilot supply chain analysis occurred in the Western Montana Corridor, a region with the potential to supply aviation fuels to regions east of the Cascade Mountains via the Yellowstone Pipeline. Two viable sites were delineated for redevelopment, Libby and Frenchtown, MT. These sites are both brownfields and are dormant forest products facilities with existing rail transportation, water rights, environmental permitting, and energy plants. In addition, Frenchtown was the site of a former pulp mill owned by Smurfit-Stone. In addition to the previously stated assets, an existing wastewater treatment and feedstock preparation facility is in place. Although further analysis is required to value these assets, their usefulness to industrial development is readily apparent. This same effort is beginning west of the Cascade Mountains where a host of facilities exist including pulp mills, forest products depots, and ethanol plants.

Reducing operating costs of a biorefinery presents greater challenges, but with $0.45 of every dollar being expended on variable operating costs, potential exists. Several tasks within the existing NARA project are already aimed at this opportunity. For instance, the Pretreatment and Conversion Teams are focused on increasing yield and decreasing chemical and energy inputs. Successes in these areas are important to decreasing the operating costs. However, the largest single cost center in the entire analysis is the feedstock cost, which in turn is dominated by transportation costs. Several variables (e.g. on-site drying, grinding efficiency, truck packing, etc.) are already aimed at decreasing feedstock costs, but the limits of these activities are likely to be ca. 20% improvements.

Table 4.1.1. Summary of commercial cellulosic biofuels projects

Source	Facility	Process	Fuel Product	Feedstock	Rated Capacity (million gal/yr)	CapEx (million)	CapEx/ Capacity (per gal capacity)
Brown and Brown	Kior	pyrolysis & hydrotreat	hydrocarbons	loblolly pine residuals	41	$350	$8.54
2013	ClearFuels	gasification & FT	hydrocarbons	woody biomass	20	$200	$10.00
	Sundrop Fuels	gasification and MTG	hydrocarbons	mixed biomass & NG	50	$500	$10.00
	ZheaChem	acid hydr & ac. acid syn	ethanol	poplar & ag residue	25	$391	$15.64
	Abengoa	enzymatic hydrolysis	ethanol	corn stover	25	$350	$14.00
	Beta Renewables	enzymatic hydrolysis	ethanol	Arundo donax	20	$170	$8.50
	DuPont Biofuels	enzymatic hydrolysis	ethanol	corn stover	25	$276	$11.04
	POET	enzymatic hydrolysis	ethanol	corn stover & cob	25	$250	$10.00
Lane 2013a	Aggregated				266	$2,719	$10.22
Lane 2013b	Estimate						$6 to $12
NARA TEA	Integrated Greenfield	enzymatic hydr to IPK	IPK	forest residuals	32	$881	$27.24
		enzymatic hydr to IBA	IBA	forest residuals	45	$881	$19.39
		enzymatic hydr to IBA	EtOH Equiv	forest residuals	68	$881	$13.02

Dramatic reductions in feedstock costs will only be achieved by decreasing transportation distance. Unfortunately, as the size of the biorefinery increases to develop processing economies of scale, feedstock costs increase disproportionately, as the plant must source raw material over longer distances.

The concept of biomass depots has been discussed recently by a number of groups and is recommended for study. (Feedstock Logistics 2010) In concept, these depots would function as concentration facilities that draw biomass from a smaller fiber-shed, prepare that material, and ship it to conversion facilities. In a recent feedstock sourcing study of the Western Montana Corridor (Figure 4.1.2), functioning and dormant primary wood processing facilities were identified and screened for rail sitings. These facilities automatically have regional harvest occurring, since sawlogs are typically the highest value products. Using these existing assets as potential biomass depots could supply adequate quantities of biomass at more acceptable transportation costs by transferring to rail at the depot. This analysis demonstrates that depots can increase biomass volumes at cost, but it is not as readily apparent that they can drive dramatic decreases in feedstock costs at volume. Further study will better discern this potential.

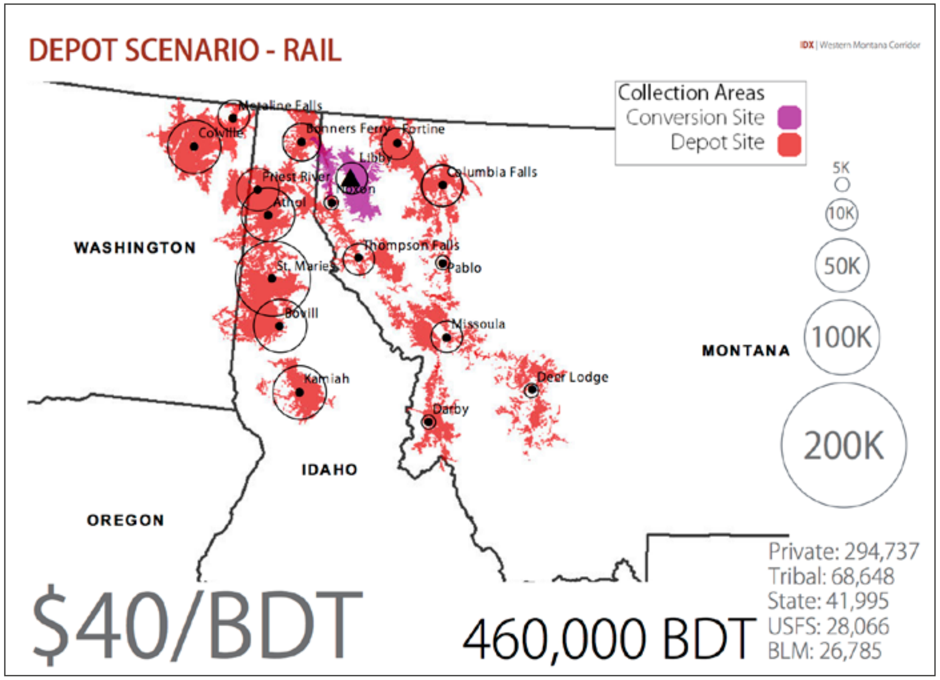

Figure 4.1.2 Example depot model for feedstock sourcing in the Western Montana Corridor

One additional approach that may be successful is to conduct more of the processing at the depot to facilitate shipping of either pretreated or saccharides feedstock. In these cases, increasing the energy density of the shipped product would additionally decrease transportation costs. However, to realize these logistical savings pretreatment methods that can be cost effectively operated at small scales are necessary.

Biofuels has had the support of recent federal administrations and congresses. This support has been manifested in the original Renewable Fuel Standard (RFS1), enacted under the Energy Policy Act (EPAct) of 2005, and further expanded into RFS2 under the Energy Independence and Security Act (EISA) of 2007 (EPA 2013). RFS2 sets mandates for biofuels production in the U.S., and if enforced, this mandate could assist in bringing biofuels to commercial scale much faster than if left solely to market forces.

The mechanisms by which the EPA intends to enforce the RFS mandates are Renewable Identification Numbers (RINs). RINs are unique 38-character numbers assigned to each gallon of renewable fuel and issued to biofuels producers or importers at the point of production or importation (Yacobucci 2012). A RIN market has developed for the buying, selling, and trading of RINs once they are separated at blending. RINs are valid for two years, and blenders or exporters that have met RFS mandates may opt to sell their excess RINs, or keep them for the following year's requirements, but no more than 20% of a specific year's Renewable Volume Obligation (RVO) requirements may be met by previous year's RINs (Yacobucci 2012). This could be an additional revenue stream for blenders or exporters, which could stimulate the markets to quicker biofuels adoption. Speculators may also opt to purchase RINs and resell them, something akin to a day trader on the stock market. With respect to NARA, the fact that biojet does not currently have an annual volumetric mandate under RFS means that blenders that produce jet fuel blends do not have to turn those specific RINs into the EPA to meet any volumetric obligations. These RINs could subsequently be sold on the RIN market at 100% profit to the blender. The blender could opt to use these RINs to meet other volumetric mandates under RFS if it was economically more beneficial to do so. Regardless of the specific directions, an understanding of RIN valuation and its impact on the economics of fuels production is vital to the development of the biofuels industry. See Appendix A for further information regarding RINs and the RFS.

4.1.3 Strategic Future Directions

Given the need to decrease capital costs along with feedstock costs, we recommend focusing on the following:

- Continue seeking regional assets that might be retrofit for an emerging biofuels industry. These facilities would include primary wood processing plants for depots, pulp plants for pretreatment and hydrolysis, and ethanol plants for fermentation.
- Inventory the specific assets at these sites and value their potential using future versions of the TEA.
- Develop a process-modeling task to predict the mass and energy balance for the plants. The models should be constructed to facilitate studies addressing production scale and dispersed supply chain production (i.e. rather than only integrated facilities).
- Advance the logistical and economic studies of feedstock supply from solids depots (i.e. solids in/solids out via simple feedstock preparation) to liquids depots utilizing distributed production of sugars.
- Continue supporting pretreatment technologies that have the potential for economic viability at small scale. Wet oxidation is one such technology, but others should be sought and explored.

4.1.4 References

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4.2 LIFE CYCLE ASSESSMENT

4.2.1 Methodology

Life cycle assessment (LCA) identifies the environmental impacts of a product or activity over its entire life cycle. NARA performed a comprehensive LCA of the WMC region to accurately estimate the environmental footprint of a woody biomass based biojet fuel supply chain in this region.

LCA is a computational tool that transcends disciplinary boundaries and can be used to evaluate the environmental sustainability of a biojet fuel industry, especially within a particular region. LCA examines the supply chain from the forest to delivery of the biojet fuel to the market. LCAs are categorized into the following modules: woody biomass collection and processing within the forest including delivery to depot facilities; conversion of the forest residues to isobutanol and delivery to the biojet fuel production facility; conversion of isobutanol to jet fuel including transportation to the end user;and conversion of the byproducts derived from the isobutanol and jet-fuel production processes into useful co-products.

In order to accurately estimate the environmental footprint of a woody biomass based biojet fuel supply chain, an integration of knowledge and research from the fields of forestry, logistics, energy economics and chemical engineering is crucial. In the analyses we explored factors that drive the differences in estimates of the new emissions of biofuels relative to fossil fuels and examine variations in key assumptions that have been identified as sources of debate regarding the accuracy of biofuel LCAs.

The results of the LCA will help forest managers and biofuel processing facilities to evaluate biomass recovery options as they pertain to the environmental impacts of the gathering and processing of forest residuals after harvest and conversion into biojet fuel. The environmental impacts will be measured utilizing L CA following the protocols set up by the environmental management standard ISO 14044 (International Organization for Standards 2006a and 2006b). By evaluating the process of extracting and processing forest residuals into biojet fuel, managers can evaluate if there is a need for increased efficiency of the operations, and if the viability and availability of the feedstock are enough to meet economic thresholds for actual use as an alternative fuel source.

4.2.2 Preliminary Findings

This section presents the preliminary results of a life-cycle assessment (LCA) for woody biomass based biojet fuel. The LCA team has evaluated multiple logistical/procedural pathways for biomass transportation scenarios. The following results present the findings of the dominant, or most likely, scenario; and incorporate the avoided environmental costs associated with piling and burning forest residuals (e.g., slash) left in the forest.

Various pretreatment options are currently being evaluated for their technical, economic and environmental feasibility. The LCA results presented here assume an integrated model (similar to the NREL process), where the biomass preconversion, pretreatment and fuel conversion processes are all undertaken at the same location. Two sets of results are presented in the following sections. The first section presents the LCA results of woody biomass collection and delivery at the preconversion facility. The environmental indicators reported for this set of results include global warming, acidification, smog, and ozone depleting potentials. The second set of results represents the complete LCA from ‘Wood to Wing’. However, due to the uncertainty associated with the pretreatment and logistics and the sensitivity of the data, only three indicators are presented, namely, global warming, ozone depletion and fossil fuel reduction potentials. Please note: These are not final LCA results for the region. Various pretreatment and feedstock logistics options are currently being evaluated for their technical, economic and environmental feasibility. Final results will be available once these pathways are finalized.

AVOIDED ENVIRONMENTAL BURDENS OF SLASH PILE BURNING:

The results of a comparative LCA analysis of the avoided environmental costs and impacts of using woody biomass residuals for biojet fuel instead of slash pile burning are noteworthy. Forest residuals in the WMC region, which are typically left in the forest after harvest, are burned to avoid fuel accumulation on the forest floor. Compared to the alternative of burning the left over slash piles from harvesting, the environmental impacts of extracting and hauling these residuals to market can be measured by the amount of carbon (CO2) emitted into the atmosphere. Emissions generated for both scenarios were calculated to provide additional credence for the utilization of leftover residuals instead of burning the slash piles that emit unfiltered smoke and ash. Environmental burdens were measured in terms of global warming, acidification, smog, and ozone depleting potentials. The results reveal that the avoided greenhouse gas (ghg) emissions from slash pile burning balances out the overall ghg emissions from woody feedstock collection and transportation under the assumed scenario. Moreover, there is a net reduction in the environmental impact resulting from extraction of residuals for the biojet fuel project by avoiding slash pile burning for the following indicators: smog formation, acidification, and respiratory effects. A summary of the results are presented in Table 4.2.1.

COMPARATIVE ANALYSIS: ENVIRONMENTAL IMPLICATIONS

Comparative Analysis: Environmental Implications of NARA Bio-Jet Fuel vs Fossil Based Bio-Jet Fuel Comparable aircraft utilizing biofuels or fossil fuels emit similar levels of carbon dioxide (CO2), which is the primary source of greenhouse gas emissions. However, the primary distinction between biofuels and fossil fuels is the source of carbon stored in the fuel. The environmental footprint associated with burning aviation fuels comes from two primary sources. First, the carbon stored in the aviation fuels is released during combustion. Second, there are significant emissions associated with the extraction, transportation and processing of crude oil into jet fuel.

The use of fossil aviation fuels releases geologic carbon that has been stored for millions of years, and those emissions represent a net addition of CO2 to the atmosphere. The NARA biojet fuel uses wood residue derived from timber harvest operations as the raw material to produce isoparaffinic kerosene (IPK) jet fuel. Trees use atmospheric carbon dioxide to grow and burning biofuels simply releases this sequestered carbon dioxide back into the environment. With a sustainable resource harvest system, where the biomass extracted from the forest is less than the biomass growth during a specified time frame, the net addition of CO2 into the atmosphere is negative. However, the conversion of forest woody residue to biojet fuel requires various inputs from nature (the atmosphere) and industry (the technosphere). Hence, the overall environmental footprint associated with biojet fuel includes all the resources used, emissions and waste generated during the process of biomass growth, collection and conversion into biofuel.

The comprehensive Life Cycle Assessment (LCA) based ‘cradle to grave’ estimation approach used to calculate the overall environmental footprint of these two types of aviation fuels is generally considered to be the most credible. The preliminary results obtained from the ‘forest to pump’ LCA analysis are carried forward to combustion in a jet engine during an intercontinental passenger flight to provide a ‘forest-to-wake’ analysis. These results are compared to the same results obtained from combustion of fossil fuel based jet fuel. The preliminary results of this LCA comparison suggest that the overall global warming potential of the NARA biojet fuel, measured in kilograms of Co 2 emissions, is just 38.4% that of fossil fuel based jet fuel (Table 4.2.2). In addition, the ozone depletion potential of the NARA biojet fuel is approximately 12% that of fossil fuel based jet fuel while the fossil fuel depletion potential is 39.1% of fossil based jet fuel. In other words, our preliminary analysis suggests that there is a 61.6% reduction in the global warming potential, an 88.1% reduction in the ozone depletion potential and a 60.7% reduction in fossil fuel depletion by substituting biojet fuel for fossil fuel based jet fuel. This preliminary result is significant in that it exceeds the mandated 60% emission reduction criterion specified in the US Energy Independence Act guidelines. Table 4.2.2 and figure 4.2.1 show the emissions associated with biojet and fossil based jet fuel in an intercontinental flight.

Table 4.2.1. Preliminary analyses of the emissions reduction associated with biojet fuel used as a substitute for fossil based jet fuel in an intercontinental flight

Impact Category	Unit	System Impact	Avoided Impact	Total Impact
Global Warming	kg CO^2 eq	65.71	-65.7	0.006
Smog	kg O^3 eq	28.8	-89.5	-60.7
Acidification	mol H+ eq	52	-176	-124
Ozone Depletion	kg CFC-11 eq	2.7 IE-09	-3.26E-10	2.3E-09
Respiratory Effects	kg PM 1- eq	0	-11.1	-11.1

Table 4.2.2. Preliminary analysis of the emissions associated with aircraft transportation of one person for 1 kilometer on an intercontinental flight

Impact Category	Unit	Bio-Jet Fuel	Fossil Fuel (Kerosene)
Ozone Depletion	kg CFC-11 eq	1.69E-06	1.42E-05
Global Warming	kg CO^2 eq	32.32	84.22
Fossil Fuel Depletion	MJ Surplus	65.17	165.79

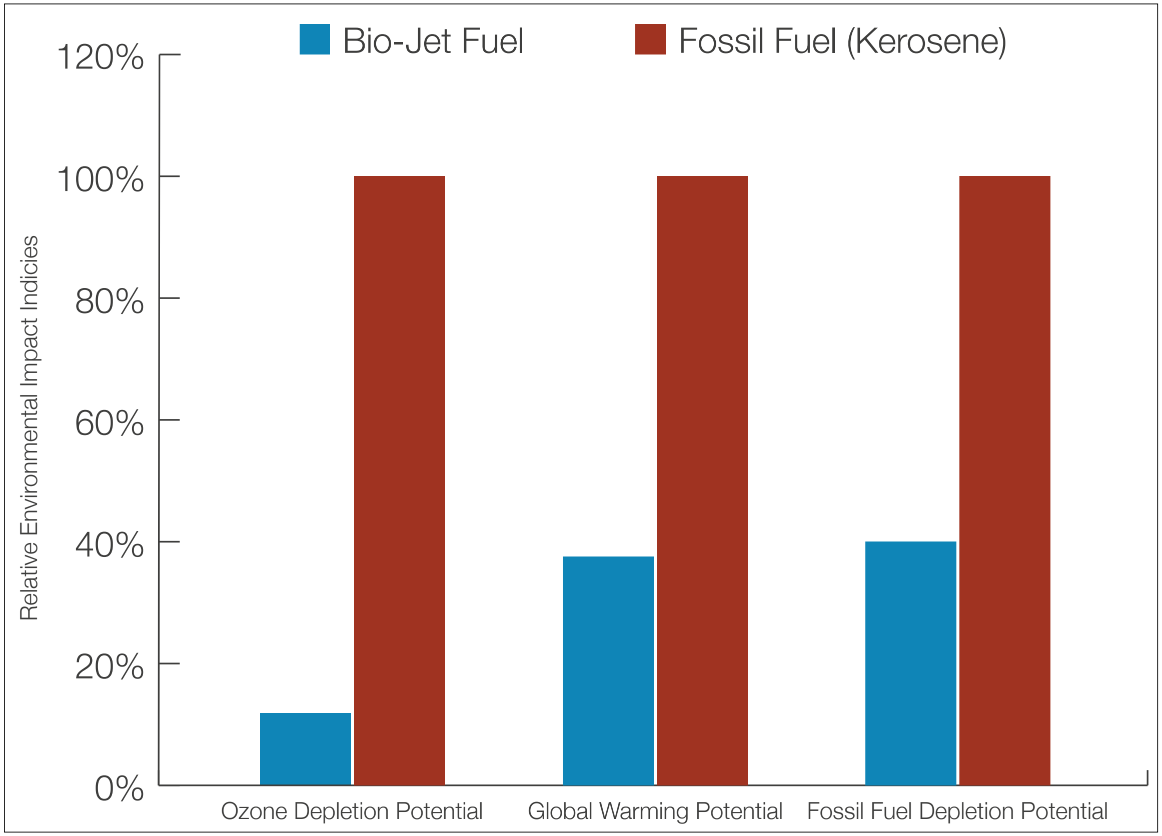

Figure 4.2.1 Preliminary analyses of the emissions reduction associated with biojet fuel used as a substitute for fossil based jet fuel in an intercontinental flight

4.2.3 References

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4.3.1 COMMUNITY IMPACT EXECUTIVE SUMMARY

4.3.1.1 Project Purpose

An input-output model is created for the Western Montana Corridor (WMC) region and used to measure the impact on county-level economies from the production of biofuels using forest residues as the feedstock. This project is a first attempt to study and measure the importance of the production of biojet fuels using forest residue feedstock to the local economies and its impact on the livelihood and businesses within the WMC region. A similar analysis will be completed for the western region of Oregon and Washington. Improvements in methodology and estimates of expenditures realized in that study will be applied to this study as they are made.

4.3.1.2 Data Collection

The study utilizes three major data sources. County-level data for transactions were provided by the Minnesota IMPLAN Group. Forest residue data were provided by the University of Montana, Bureau of Business and Economic Research, who are contracted by the U.S. Forest Service to quantify all timber harvests and sales, and the flow of the wood products through processing plants and to the end users. Their data is summarized in a Timber Product Output report for each state that they monitor. This data was used to construct estimates of unutilized forest residues for the WMC. Expenditure data for the biojet fuel refinery were taken from a techno-economic analysis completed as part of the larger Northwest Advanced Renewables Alliance (NARA) study on biojet fuel production using forest residue feedstock.

4.3.1.3 Methodology

The study uses input-output analysis to examine how economic activity flows through the economy to generate additional indirect and induced impacts. Indirect impacts measure the effects of direct economic impacts on other connected businesses. Induced impacts measure the spending effects by households associated with direct and indirect impacts.

IMPLAN data was used to create a workbook-based model to measure the direct and indirect impacts. IMPLAN data on employment and value added, i.e., wages, and other income, was also used to make households behave like industries by selling their services, earning revenues and making purchases, thereby allowing the induced effects to be calculated using the value-added multiplier.

The workbook-based model is an economic account at the county level from which multipliers are calculated. The multipliers form the basis to measure economic impacts from new activity. Impacts from added economic activity associated with biojet fuel production are entered in a spreadsheet linked to county multipliers. Then, direct, indirect and induced effects are summarized.

The estimates are believed to be conservative. We use a conservative market price for forest residues to estimate the added activity in the feedstock delivery market. We also do not correct for leakage from purchases made within the WMC region when using economic accounts at the county level. Leakage in input-output terminology refers to purchases made outside of the region, i.e., the payments for imported goods and services. Since the economic effects of these purchases occur outside of the region, their impacts are not counted, e.g., when analysis of economies at the county level were done, purchases that were likely to be made in nearby counties that are inside the WMC boundary were not counted as part of the county's domestic product.

4.3.1.4 Results

We report results for the impacts of added economic activity due to additional forest residual harvests and their associated effect on the forestry and transportation sectors. We also report the results for the impact of a hypothetical biojet fuel plant with co-product production. The sum of these impacts constitutes the economic impact of new biorefinery production in the WMC.

An estimated $46 million (valued at $65/BDT delivered) spend by a hypothetical biojet fuel refinery on forest residue feedstock creates a direct and indirect economic impact of $74 million. Seven hundred thirty-six new jobs are created with nearly $36 million in value added, i.e., the induced effect. The sum of these direct, indirect and induced economic effects totals $110 million annually. This impact measures only the expenditure associated with feedstock purchases.

An estimated $203 million annually spend by a hypothetical biofuel refinery on variable inputs, such as labor and materials, creates a direct and indirect economic impact of $459 million. One thousand seven hundred fifty four new jobs are created with slightly over $143 million in value added (induced effect).

The combined effect of $249 million expenses results in $533 million dollars in direct and indirect economic impact with nearly twenty five hundred new workers and $179 million in value added. The sum of these direct, indirect and induced economic effects totals $822 million annually.

The distribution of the effects can be significant for several county-level economies. The distributional effect is due to the locational aspects of forest residue production. In five counties, the added economic activity created by new demand for feedstock by the biorefinery is significant, representing increases from 0.9% to 1.5% new gross domestic product.

The biorefinery operation, without feedstock purchases, creates a larger indirect effect than induced effect; whereas feedstock purchases create a larger induced effect than indirect effect. This is a result of the intensity of labor use in each of these activities: the biorefinery operation, sans feedstock purchases, is more capital intensive than the feedstock purchasing enterprise. Whereas the employment coefficient calculated from employment numbers and industrial output reported by IMPLAN associated with the forestry/fishery sector is quite high.

New estimates of feedstock availability and improvements in expenditure data are being calculated by NARA members as the project progresses. We will use these estimates when made available to revisit the economic impacts on rural communities within the WMC and the broader NARA region.

4.3.2 INTRODUCTION

The report describes and quantifies the magnitude of economic activity accounted for by the introduction of a new biojet fuels refinery in the Western Montana Corridor (WMC). We measure three aggregate economic impacts: total economic output, value-added and employment. Value-added and employment impacts are used to calculate average wage benefits associated with the added economic activity.

The impacts are measured with an input-output model created for the WMC region. The model consists of economic accounts for each county in the WMC region. Economic activity is county specific, such as the case of forest residual harvests, and, in those instances, is summed to get the impact measure for the WMC region. The accounts are stored as individual spreadsheets within an Excel workbook and can be used by community planners and others to analyze other issues related to economic development in the WMC region.

An important consideration in defining the boundaries of the economic analysis is that of leakage due to the need to purchase goods and services outside of the region. A percentage of county-level purchases are likely to be made outside of the county but within the WMC region and are not accounted for. Hence the estimates of economic impacts are considered to be conservative.

4.3.3 THE INPUT-OUTPUT TABLE FOR WMC

4.3.3.1 Description of the Transaction Table

The transaction table is a detailed set of economic activity measuring purchases and sales by industry and household and government institutions. IMPLAN data for 2011 for each county in the WMC region is used to construct the transaction table. Since the focus of the exercise is industry impacts we focus on an industry-by-industry transaction table and calculate the induced effect using household purchase data. The industry-by-industry transaction table consists of inter-industry transactions, also called intermediate demand, final demand transactions with consumers such as households, government, capital goods sector and markets outside the region, and a third section, final payments, also called primary inputs.

4.3.3.2 Definitions and Conventions

REGION

The geographical region is the 37 counties in three states known as the Western Montana Corridor (WMC). The region is bounded by Spokane and Pend Oreille counties in eastern Washington on the west to Yellowstone County in Montana on the east. Lemhi County, Idaho forms the southwest corner and Toole County, Montana forms the Northeast corner (Figure 4.3.1).

BASE YEAR

The base year for the analysis is 2011.

SECTORING PLAN

Sectors were aggregated at two levels: a 10 sector model and a 66 sector model. The 10 sector model is developed mainly to allow ease of model development using a smaller number of sectors, and to determine the sensitivity of the models to sector aggregation. We report results using the 66 sector model. Table 4.3.1. describes the 66 sectors.

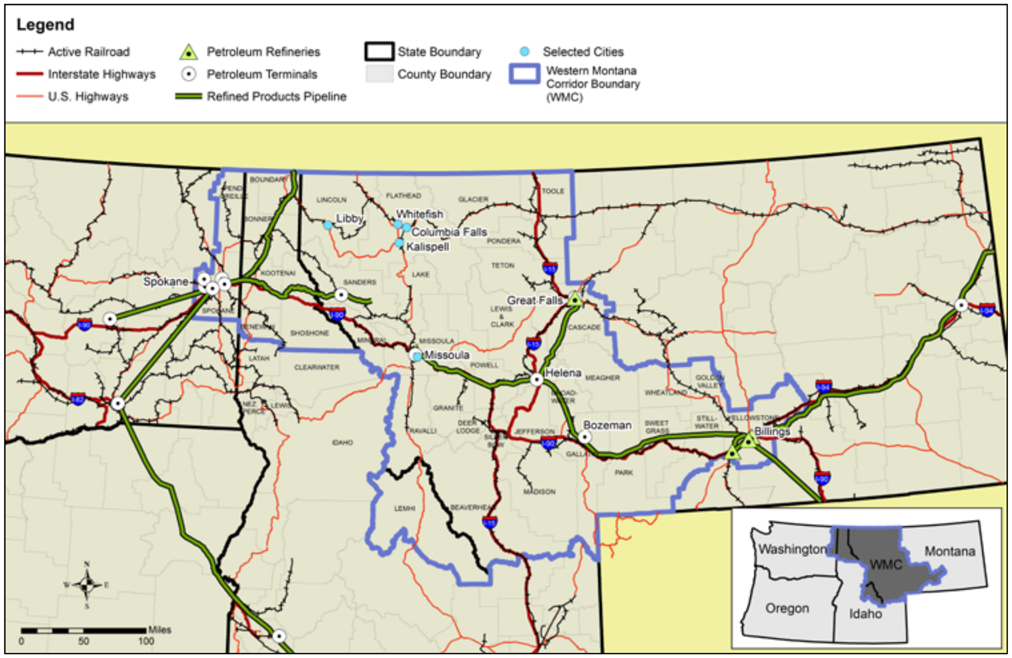

Figure 4.3.1 Map of the Western Montana Corridor region

Table 4.3.1. Numbering and naming convention with a description of sectors

Sector Number	Sector Name	Sector Description
1	FARMS	Farms
15	FORFISH	Forestry fishing and related activities
20	OGEXTRACT	Oil and gas extraction
21	MINING	Mining except oil and gas
28	MINESUP	Support activity for mining
31	UTILITIES	Electricity and other utilities
34	CONSTR	Construction and maintenance activities
41	FOOD	Food beverage and tobacco
75	TEXTILE	Textile mill and textile products
86	APPAREL	Apparel and leather and allied products
95	WOODPROD	Wood products
104	PAPER	Paper products
113	PRINT	Printing activities
115	PETRO	Petroleum and coal products
120	CHEM	Chemical Products
142	PLASTIC	Plastic and rubber
153	NOMETAL	Nonmetallic mineral products
170	PRIMMETAL	Primary metals manufacturing
179	FABMETAL	Fabricated metals manufacturing
203	MACH	Machinery
234	COMPELEC	Computer and electronic products
259	ELECEQ	Electrical equipment appliances and components
276	MOTORV	Motor vehicles bodies trailers and parts
284	OTHTRANS	Other transport equipment
295	FURNITURE	Furniture and related
305	MISCMANU	Miscellaneous manufacturing
319	WHOLE	Wholesale trade
320	RETAIL	Retail
332	AIR	Air transportation
333	RAIL	Rail transportation
334	WATER	Water transportation
335	TRUCK	Truck transportation
336	TRANSIT	Transit and ground transportation
337	PIPE	Pipeline transportation
338	OTHERTRANS	Other transportation and support activities
340	WHARE	Warehousing and storage
341	PUBLISH	Publishing
346	MOTION	Motion pictures and sound recording industries
348	BROAD	Broadcasting and telecommunications
350	INFO	Info and data processing industries
354	FED	Federal reserve bank
356	SECURITIES	Securities commodity contracts and investments
357	INSURE	Insurance carriers and related activities
359	TRUSTS	Funds trusts and other financial instruments
360	REALES	Real estate
361	IMPUTE	Inventory adjust and owner occupied dwellings
362	RENT	Rental and leasing services
367	LEGAL	Legal services
368	MISCSERV	Miscellaneous services
371	COMPU	Computer system designs and related services
381	MANAGE	Management and support services
382	ADMIN	Administrative and support
390	WASTE	Waste management services
391	EDUC	Educational services
394	AMBUL	Ambulatory health care services
397	HOSPI	Hospital and nursing services
399	SOCIAL	Social services
402	PERF	Performing arts and related activities
407	AMUSE	Amusement industries
411	ACCOM	Accommodations
413	FOODSER	Food services and drinking places
414	OTHERSER	Other services except government
427	FEDENT	Federal enterprises
430	STATEENT	State enterprises
437	STATEPAY	State general
439	FEDPAY	Federal general

4.3.4 APPLICATION OF THE INPUT-OUTPUT MODEL

4.3.4.1 Descriptive Analysis

Employment in the WMC region was 928,817. Industrial output is the sum of the value added across all sectors in the economy plus intermediate demand from industrial uses and reached nearly $120 billion. Gross regional product, measured as value added, which is the sum of wages and other incomes paid, totaled $63 billion.

Table 4.3.2 presents the employment, gross regional product (value added), and industrial output by county. Spokane is the county with the largest economy representing 29%, 31%and 28% of employment, value added and industrial output within the WMC region respectively. Golden Valley is the county with the smallest economy representing less than 0.1% of the regional economy in employment, value added and industrial output.

Table 4.3.2. Employment Value added and industrial output by county in the WMC region

County	Employment	Percent	Value Added ($MM)	Percent	Industrial Output ($MM)	Percent
Beaverhead	5,618	0.60%	$401	0.63%	$764	0.64%
Benewah	4,937	0.53%	$280	0.44%	$533	0.45%
Bonner	22,985	2.47%	$1,279	2.02%	$2,604	2.18%
Boundary	5,328	0.57%	$284	0.45%	$568	0.47%
Broadwater	2,141	0.23%	$119	0.19%	$247	0.21%
Cascade	50,890	5.48%	$3,894	6.14%	$7,718	6.45%
Deer Lodge	5,413	0.58%	$286	0.45%	$462	0.39%
Flathead	58,176	6.26%	$3,394	5.35%	$6,393	5.34%
Gallatin	64,896	6.99%	$3,781	5.96%	$6,732	5.62%
Glacier	7,066	0.76%	$452	0.71%	$760	0.64%
Golden Valley	546	0.06%	$22	0.04%	$52	0.04%
Granite	1,862	0.20%	$81	0.13%	$173	0.14%
Jefferson	5,731	0.62%	$352	0.55%	$637	0.53%
Kootenai	74,883	8.06%	$4,486	7.07%	$8,521	7.12%
Lake	13,428	1.45%	$715	1.13%	$1,308	1.09%
Lemhi	3,730	0.40%	$224	0.35%	$390	0.33%
Lewis and Clark	53,608	5.77%	$3,577	5.64%	$5,399	4.51%
Lincoln	8,812	0.95%	$562	0.89%	$1,021	0.85%
Madison	5,688	0.61%	$307	0.48%	$597	0.50%
Meagher	891	0.10%	$49	0.08%	$100	0.08%
Mineral	2,020	0.22%	$98	0.16%	$194	0.16%
Missoula	73,139	7.87%	$4,419	6.96%	$7,796	6.51%
Park	9,268	1.00%	$465	0.73%	$905	0.76%
Pend Oreille	4,554	0.49%	$341	0.54%	$625	0.52%
Pondera	3,328	0.36%	$188	0.30%	$417	0.35%
Powell	5,029	0.54%	$266	0.42%	$417	0.35%
Ravalli	18,459	1.99%	$970	1.53%	$1,921	1.61%
Sanders	5,144	0.55%	$284	0.45%	$546	0.46%
Shoshone	6,743	0.73%	$566	0.89%	$970	0.81%
Silver Bow	19,769	2.13%	$1,785	2.81%	$3,079	2.57%
Spokane	265,390	28.57%	$19,865	31.30%	$33,339	27.85%
Stillwater	5,243	0.56%	$674	1.06%	$1,086	0.91%
Sweet Grass	2,559	0.28%	$232	0.37%	$386	0.32%
Teton	4,065	0.44%	$250	0.39%	$530	0.44%
Toole	3,559	0.38%	$277	0.44%	$534	0.45%
Wheatland	1,088	0.12%	$56	0.09%	$152	0.13%
Yellowstone	102,830	11.07%	$8,181	12.89%	$21,830	18.24%
Total	928,817	100.00%	$63,462	100.00%	$119,706	100.00%

4.3.4.2 Impact Analysis

TECHNICAL INPUT-OUTPUT

The possible introduction of a new bioenergy sector in the WMC that utilizes manufacturing plants, equipment, labor, and forest residue feedstock, among other variable inputs, to produce biojet fuel creates economic activity. We measure the impact from this new economic activity by developing input-output tables that examine the expenditures made by paying wages to variable inputs, workers and feedstock. The analysis of expenditures together with the use of input-output models allows us to measure how the direct economic effects ripple through the economy to generate additional indirect and induced impacts. Indirect impacts measure the effects of purchases by forest-related businesses for their variable inputs on the economy. Induced impacts capture spending by, say, the forestry firm's labor force and owners as well as the wages and dividends they earn. Knowing the expenditure profile of the bioenergy sector allows the estimation of the total (direct and indirect) economic impact using input-output tables. Induced impacts can be estimated by applying wage and dividends generated by the firm to an average household expenditure pattern and then by estimating the ways in which these expenditures produce further economic activity.

We report results on three measures of impact defined below: 1. Direct and indirect impacts: Added industrial output directly and indirectly attributed to new expenses made; 2. Induced effects: Value of compensation (wages, benefits and other income sources) paid to employees and owners and the ripple effect through the economy; 3. Employment: Number of jobs.

Aggregation of sectors is completed using IMPLAN modeling software. An alternative aggregation software using GAMS was also developed and compared to IMPLAN-derived matrices. The principle differences between the two are assumptions regarding the value of trade contained in the transaction tables. Transaction tables produced using the IMPLAN modeling software are then imported into spreadsheets that calculate direct purchase coefficients, and from these coefficients, multipliers for each aggregated sector.

TECHNICAL INPUT-OUTPUT

Multipliers are calculated using IMPLAN data on industry transactions for 10 and 66 sector models. Table 4.3.3 presents the multipliers calculated for Toole County for the 10 sector model as an example. It includes the multiplier associated with value added (last row). The value-added multiplier is the total value added generated in all sectors of the economy per dollar of output in the industry. It is used to calculate the induced effect, and works with the personal consumption expenditure (PCE) (last column). The multiplier table is a square table (number of rows equals the number of columns) with the values in the diagonal cells equal to the direct effect, and numbers off-diagonal under the sector-heading column equal to the indirect effects. Column sums, excluding the value added multiplier, gives the total (direct and indirect) economic effect. For instance, the total effect per dollar of output in the AG industry is $1.60, i.e., the sum of 1.10814 through 0.01323.

Table 4.3.3. Multipliers for the 10 sector model and value added sector for Toole County

SECTOR	AG	MINING	UTILITIES	CONST	MANUF	WHOLE	RETAIL	TRANSWHR	SERVICES	GOVT	PCE
AG	1.10814	0.00439	0.00391	0.00410	0.02096	0.00447	0.00000	0.00289	0.00431	0.00424	0.00432
MINING	0.04199	1.12489	0.24234	0.04319	0.14776	0.02739	0.00000	0.04104	0.02709	0.02913	0.02508
UTILITIES	0.03356	0.04664	1.02925	0.02321	0.03174	0.03355	0.00000	0.02264	0.03154	0.02927	0.02847
CONST	0.00716	0.04512	0.02685	1.00444	0.01039	0.00628	0.00000	0.01122	0.00941	0.00604	0.00376
MANUF	0.01029	0.00900	0.00728	0.01006	1.01535	0.00635	0.00000	0.01083	0.00628	0.00633	0.00605
WHOLE	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000
RETAIL	0.06088	0.06724	0.08143	0.09903	0.05999	0.09143	1.00000	0.06195	0.07769	0.09900	0.10145
TRANSWHR	0.03850	0.04179	0.07780	0.03060	0.03969	0.05682	0.00000	1.12448	0.03198	0.02832	0.02727
SERVICES	0.28990	0.42167	0.41878	0.36211	0.25071	0.47471	0.00000	0.36103	1.52523	0.42770	0.43015
GOVT	0.01323	0.01771	0.01659	0.01274	0.01232	0.02243	0.00000	0.02763	0.02000	1.01636	0.01572
Value added	0.57551	0.67405	0.96568	0.85569	0.39255	1.01119	0.00000	0.64936	0.90132	1.24893	1.28932

WMC MULTIPLIERS

Multipliers for the 10 and 66 sector models are contained in workbooks and are available from the authors upon requests. Included in the workbooks is an Impact Summary worksheet that calculates the total impact associated with new economic activity. In addition to industrial input-output and value-added multipliers, direct employment coefficients are calculated from estimates of employment and output in the input-output table. The coefficient measures the total number of jobs per million dollars of output, and is used to calculate the number of jobs associated with new economic activity (Table 4.3.4).

It should be noted that the employment coefficient for the forest sector calculated using IMPLAN data is fairly large. A large number of employees work in the sector with relatively small industrial output. Other sectors with large employment coefficients include social services (SOCIAL: 28.3), performing arts (PERF: 27.6), TRANSIT (22.6), forest and fisheries (FORFISH: 22.5), education (EDUC: 20.4) and food services (FOODSER: 19.0).

IMPACT ESTIMATION PROCEDURE

We measure impacts by multiplying the added economic activity by the input-output multipliers for each county that contributes new economic activity associated with forest residue production or biorefinery plant operations. We calculate the regional impact by adding county-level effects.

New economic activity is defined in two steps. A first step recognizes that forest residue production and collection occurs across the region in varying amounts. The second step assumes that the hypothetical biorefinery most resembles the existing chemical sector in its expenditures with some modifications.

Table 4.3.4. Employment coefficients by sector

Sector	Coefficient	Sector	Coefficient	Sector	Coefficient
FARMS (1)	10.2	MOTORV (276)	1.9	REALES (360)	9.1
FORFISH (15)	22.5	OTHTRANS (284)	3.0	IMPUTE (361)	0.0
OGEXTRACT (20)	3.2	FURNITURE (295)	6.3	RENT (362)	3.9
MINING (21)	2.0	MISCMANU (305)	6.0	LEGAL (367)	9.3
MINESUP (28)	2.9	WHOLE (319)	6.6	MISCSERV (368)	11.2
UTILITIES (31)	1.3	RETAIL (320)	15.0	COMPU (371)	10.1
CONSTR (34)	9.5	AIR (332)	3.9	MANAGE (381)	5.9
FOOD (41)	1.8	RAIL (333)	2.5	ADMIN (382)	18.9
TEXTILE (75)	6.2	WATER (334)	3.1	WASTE (390)	4.1
APPAREL (86)	6.8	TRUCK (335)	7.3	EDUC (391)	20.4
WOODPROD (95)	4.5	TRANSIT (336)	22.6	AMBUL (394)	9.3
PAPER (104)	1.6	PIPE (337)	1.5	HOSPI (397)	10.2
PRINT (113)	0.2	OTHERTRANS (338)	10.3	SOCIAL (399)	28.3
PETRO (115)	0.0	WHARE (340)	17.6	PERF (402)	27.6
CHEM (120)	1.2	PUBLISH (341)	5.9	AMUSE (407)	16.7
PLASTIC (142)	3.8	MOTION (346)	10.4	ACCOM (411)	10.8
NOMETAL (153)	4.0	BROAD (348)	2.5	FOODSER (413)	19.0
PRIMMETAL (170)	1.4	INFO (350)	4.8	OTHERSER (414)	14.2
FABMETAL (179)	4.7	FED (354)	3.3	FEDENT (427)	8.5
MACH (203)	2.9	SECURITIES (356)	7.4	STATEENT (430)	5.8
COMPELEC (234)	2.2	INSURE (357)	5.6	STATEPAY (437)	0.0
ELECEQ (259)	3.2	TRUSTS (359)	2.9	FEDPAY (439)	0.0

FEEDSTOCK IMPACT PROCEDURE

New economic activity associated with feedstock is calculated using estimates of the available feedstock within the WMC region, the average price of the material delivered to either a depot or the refinery site, and an estimated breakout of the activity associated with the transportation and forestry sectors.
Table 4.3.5 contains the location and volume of feedstock. A total of 705,000 bone dry tons (BDT) is assumed available. Table 4.3.5 also contains the valuation and assumed expenses by forestry and transportation sectors. The breakout of forestry and transportation sector percentage of expenses is calculated using Washington state data on forest residue production and cost. Twenty percent of the value of the forest residue is attributable to land rent; the remaining 80% is attributable to transportation. This is a first cut estimation of the breakout between the two sectors.

Table 4.3.5. The location, amount, and value of feedstock

City	County	State	Facility Type	County Forest Residue Volume (BDT)	Valued@$65/ton	20% Land	80% Transportation
Metaline Falls	Pend Oreille	WA	Depot	74,886	$4,867,590	$973,518	$3,894,072
Priest River	Bonner	ID	Depot	29,402	$1,911,130	$382,226	$1,528,904
Athol	Kootenai	ID	Depot	65,066	$4,229,290	$845,858	$3,383,432
St. Maries	Benewah	ID	Depot	93,317	$6,065,605	$1,213,121	$4,852,484
Bonners Ferry	Boundary	ID	Depot	75,233	$4,890,145	$978,029	$3,912,116
Noxon	Sanders	MT	Depot	36,081	$2,345,265	$469,053	$1,876,212
Thompson Falls	Sanders	MT	Depot	36,081	$2,345,265	$469,053	$1,876,212
Libby	Lincoln	MT	Depot/Biorefinery	50,417	$3,277,105	$655,421	$2,621,684
Fortine	Lincoln	MT	Depot	50,417	$3,277,105	$655,421	$2,621,684
Columbia Falls	Flathead	MT	Depot	69,669	$4,528,485	$905,697	$3,622,788
Pablo	Lake	MT	Depot	25,182	$1,636,830	$327,366	$1,309,464
Missoula	Missoula	MT	Depot/Biorefinery	69,498	$4,517,370	$903,474	$3,613,896
Darby	Ravalli	MT	Depot	5,462	$355,030	$71,006	$284,024
Deer Lodge	Powell	MT	Depot	24,057	$1,563,705	$312,741	$1,250,964
Total					$45,809,920	$9,161,984	$36,647,936

BIOREFINERY IMPACT PROCEDURE

The hypothetical biorefinery plant consists of estimates of the manufacturing costs to produce biojet fuels. Preliminary estimates are for a manufacturing process that includes two recently identified and quantified co-products: Lignosulfonates from spent sulfite liquor that be used in cement additives, for example, and activated carbon from hydrolyzed, fermented, distilled pulp solids. We compared the expenditures associated with the biorefinery to the wood products and chemical manufacturing sectors already existing in the WMC, and found similarities in the purchase coefficients between the biorefinery and the chemical manufacturing sector, with some noted exception. For one, feedstock purchases from the forest sector do not exist in the chemical sector. The purchase coefficients were sufficiently similar to use expenditures from the chemical sector as an initial point of investigation to study the hypothetical biorefinery (Table 4.3.6).

Table 4.3.6. A comparison of purchase coefficients between a hypothetical biorefinery and the chemical sector in the WMC

Sector	Purchase Coefficient	Purchase Coefficient
Feedstock and handling	0.10	0.08
Various materials (enzymatic, fermentation processes and others)	0.14	
Chemical sector purchases (assumed feedstock)		0.16
Utilities plus power boiler	0.03	0.03
Fixed costs (Labor, prop tax, insurance,)maintenance	0.14	0.16
Total manufacturing costs (has fixed costs, no taxes)	0.46	0.46
Income tax	0.05	0.01

Notes: Purchase coefficients (1) are for biorefinery; purchase coefficients (2) are for chemical sector. They are calculated as the value of purchases in each sector divided by the total industrial output.

4.3.5 RESULTS

Results are presented in the following order. The impacts on all sectors from expenditures on forest residues are presented first, followed by a table with the biorefinery impacts on all sectors. The two tables are used to present the economic impact associated with a new biorefinery plant located in the WMC region.

DIRECT AND INDIRECT IMPACTS

The direct plus indirect effects from feedstock purchases amount to $74 million (Table 4.3.7). These effects from biorefinery operations equal $459 million (Table 4.3.8). The expenditures combined from a new biorefinery in the WMC region sum to $533 million.

INDUCED EFFECTS

Value added from expenditures associated with forest residues amounts to $46 million (Table 4.3.7). The induced effect associated with biorefinery operations equals $143 million (Table 4.3.8). Combined, the expenditures induce household and other institutions to spend an additional $179 million.

EMPLOYMENT

Employment in the forestry and transportation sectors associated with added activity to deliver forest residue feedstock to the biorefinery amounts to 736 new employees (Table 4.3.7). The biorefinery operations add 1,754 new employees (Table 4.3.8). Together the number of new employees amount to 2,490.

Table 4.3.7. Direct, indirect and induced effects from $46 MM additional spending on feedstocks

Sector	Impacts	Unit
SECTOR IMPACTS	$74.407	$MM
VALUE ADDED	$35.860	$MM
EMPLOYMENT	736	Persons
Value Added/Employee	$48,723	$/Person

Table 4.3.8. Direct, indirect and induced effects from $203.6 MM additional spending on biorefinery operations

Sector	Impacts	Unit
SECTOR IMPACTS	$458.543	$MM
VALUE ADDED	$143.346	$MM
EMPLOYMENT	1754	Persons
Value Added/Employee	$81,725	$/Person

OTHER ECONOMIC CONSIDERATIONS

Since forest residue production occurs across different counties with varying levels, the new demand from the biorefinery operations will affect local economies according to their potential to supply residues. In some counties the impact the new economic activity created by the biorefinery installation is substantial. Five counties increase their value added (gross county output) by greater than 0.9 percentage points. Benewah County expands its gross county output by 1.5% (Table 4.3.9.)

Table 4.3.9. Percent changes in employment, value added and industrial output from new feedstock demand

	Employment	Value Added	Industrial Output
Benewah County	1.63%	1.50%	2.43%
of Total	0.01%	0.01%	0.01%
Bonner County	0.14%	0.11%	0.18%
of Total	0.00%	0.00%	0.00%
Boundary County	1.43%	1.18%	1.88%
of Total	0.01%	0.01%	0.01%
Flathead County	0.14%	0.12%	0.20%
of Total	0.01%	0.01%	0.01%
Kootenai County	0.10%	0.09%	0.14%
of Total	0.01%	0.01%	0.01%
Lake County	0.24%	0.18%	0.30%
of Total	0.00%	0.00%	0.00%
Lincoln County	1.31%	0.91%	1.55%
of Total	0.01%	0.01%	0.01%
Missoula County	0.11%	0.11%	0.17%
of Total	0.01%	0.01%	0.01%
Pend Oreille County	1.28%	0.93%	1.56%
of Total	0.01%	0.00%	0.01%
Powell County	0.45%	0.38%	0.78%
of Total	0.00%	0.00%	0.00%
Ravalli County	0.03%	0.03%	0.04%
of Total	0.00%	0.00%	0.00%
Sanders County	1.53%	1.16%	1.98%
of Total	0.01%	0.01%	0.01%
All Counties	0.08%	0.06%	0.09%

4.3.6 FUTURE WORK

We report results using IMPLAN data and models that calculate industry input-output multipliers, value-added multipliers and employment coefficients. We combine these data and models that calculate the effects new economic activity has on existing economies in the WMC region with estimates of expenditures from a hypothetical biorefinery and production of forest residues delivered to depots or a refinery. We chose to use multipliers associated with chemical sector after a comparison between expenses associated with the hypothetical biorefinery and the chemical sector in the WMC region. The study method used chemical-sector multipliers subtracting the expenses associated with feedstock purchases, and used the forest and transportation sector multipliers to assess feedstock purchases. This is akin to saying that the biorefinery operations industry has a business separate that is in charge of purchasing feedstock and then passes it along to its “parent” business, without additional charge. While the procedure produces estimates of the economic impacts, there is room to improve upon the data associated with both expenses for feedstock and biorefinery operations.

As an alternative methodology, we can insert a new biorefinery sector in the input-output tables. While data on purchases made by the biorefinery may not be lacking, data on other sector and household and government institution uses of products made by the biorefinery would be needed. We will explore this option as we develop the data and models for the western Washington and western Oregon regional study, and update this study for the WMC region.

Employment coefficients calculated from IMPLAN employment numbers seem high. Forestry is often thought of as a capital intensive industry since the time value is so high. We will investigate whether further disaggregation from fisheries affects the results presented here.

Imports play a role in determining the multipliers since they affect purchase coefficients. We assume that purchases outside the county and region reflected in the current purchase coefficients are adequate. We will continue to explore regional purchase coefficients and their methods of calculation by IMPLAN procedures.

One time purchases for the biorefinery plant are not included in the analysis and will be completed in future updates.

We will investigate the industry by commodity accounts to describe how sales of products including the co-products leads to added economic activity. The approach is related to the point raised above in paragraph 2.

New estimates of feedstock availability are being calculated using the NARA model by Darius Adams and Greg Latta out of Oregon State University. We will use these estimates when made available to revisit feedstock purchase impacts on economics in the WMC.

4.4 EDUCATION AND OUTREACH

4.4.1 Informed Stakeholder Assessment Study

In recent years, there has been significant attention paid to the technology required for the creation of biofuels from various cellulosic feedstocks. In the Pacific Northwest region of the US , this focus has resulted in several alliances addressing numerous feedstocks relevant to the region (safnw.com; nararenewables.org; ahb-nw.com). This research addressed the impacts of social acceptance on biofuel project success. While scientific, infrastructure, and community physical asset development are significant and important to the success of this emerging industry, key questions must also be addressed regarding the perceptions, experiences and potential acceptance or rejection of this emerging industry by local stakeholders and communities.

The informed stakeholder assessment study examines informed stakeholder perceptions regarding the social factors which impact a biomass-to-biojet industry based on forest residues in the WMC. Key issues under investigation using a mixed-method approach include forest management practices, trust, communication, knowledge, experience, social acceptance, local community impact, and environmental concerns.

STAKEHOLDER ASSESSMENT METHODS

A mixed methods process was used to administer an in-progress survey, which consists of open ended, multiple choice and Likert Scale questions. The instrument was pilot tested using in-person interviews with 10 WMC informed stakeholders. Using pilot test feedback and in collaboration with other USDA-NIFA agricultural and food research Initiative grant researchers the instrument was refined. Those collaborators include: Dr. Stanley T. Asah, Advanced Hardwood Biofuels Northwest (AHB), University of Washington; Dr. Sudipta Dasmohapatra, Southeast Partnership for Integrated Biomass Supply Systems (IBSS), North Carolina State University; and Dr. Darin Saul and Priscilla Salant, University of Idaho.

The preliminary findings are presented below. Data collection continues and will include additional geographic areas of interest to the NARA project in the Pacific Northwest, including the I-5 Corridor and the Columbia Plateau. Ultimately, we anticipate triangulating the results with existing county level, national, and local data sets for cross-validation and further statistical analyses to allow informed selection of optimal community sites for NARA project activities.

STAKEHOLDER ASSESSMENT FINDINGS

To date, preliminary analysis was conducted on 52 responses from the WMC; 41 surveys were completed online, one via phone interview and 10 through in-person interviews. Figure 4.4.1 shows the location of respondents in the WMC by zip code.

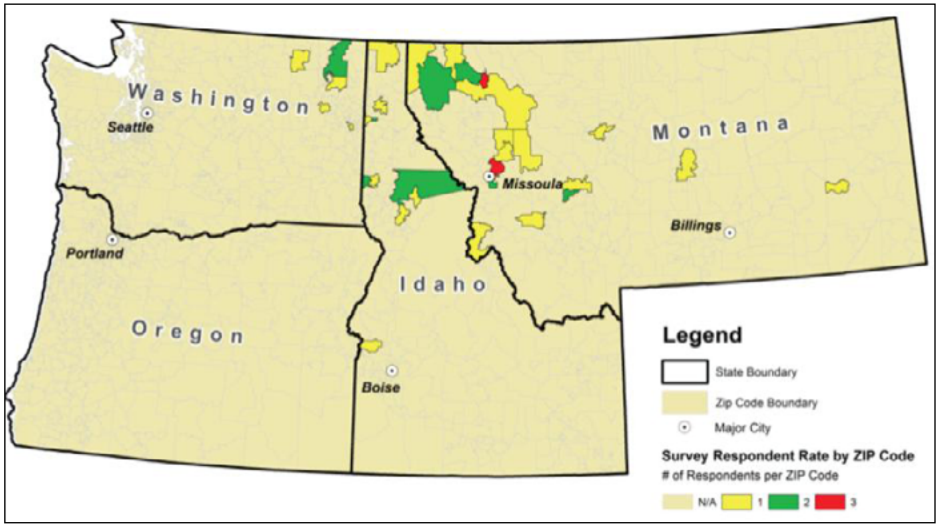

Figure 4.4.1 WMC Survey Respondents by Zip Code

Survey participants were categorized into three large stakeholder groups consisting of government, industry and environment (see figure 4.4.2). Within the government category, we included local, state and federal agencies, as well as elected officials; in the industry category we included all participants associated with private industry ranging from forest operations to refineries; the environment category captured nonprofit organizations and regional collaborative organizations. To further understand survey participants, we asked them to provide their political preference. Figure 4.4.3 shows the participants' self described political preference.

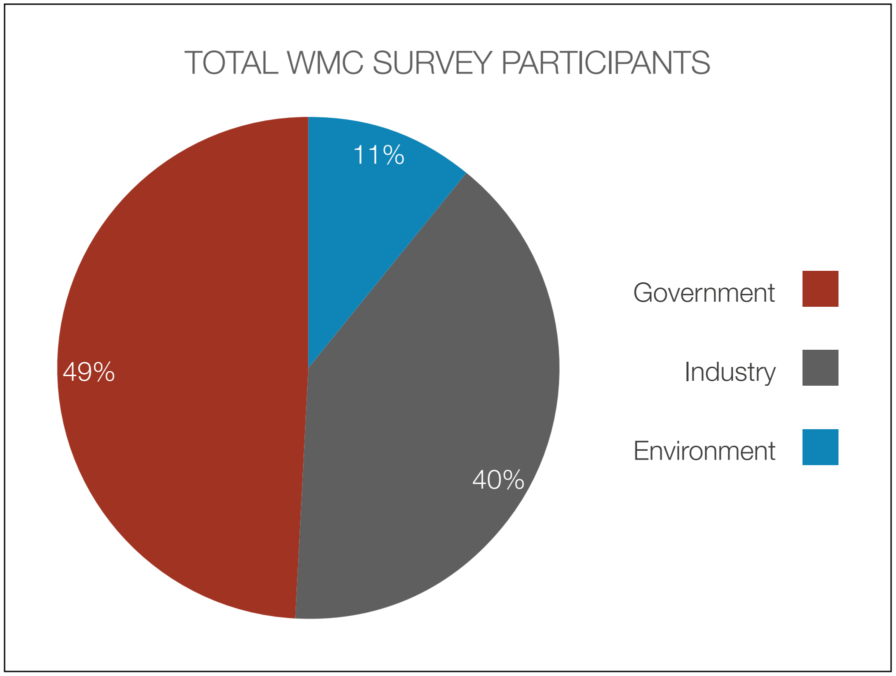

Figure 4.4.2 WMC Survey Participants by Stakeholder Category

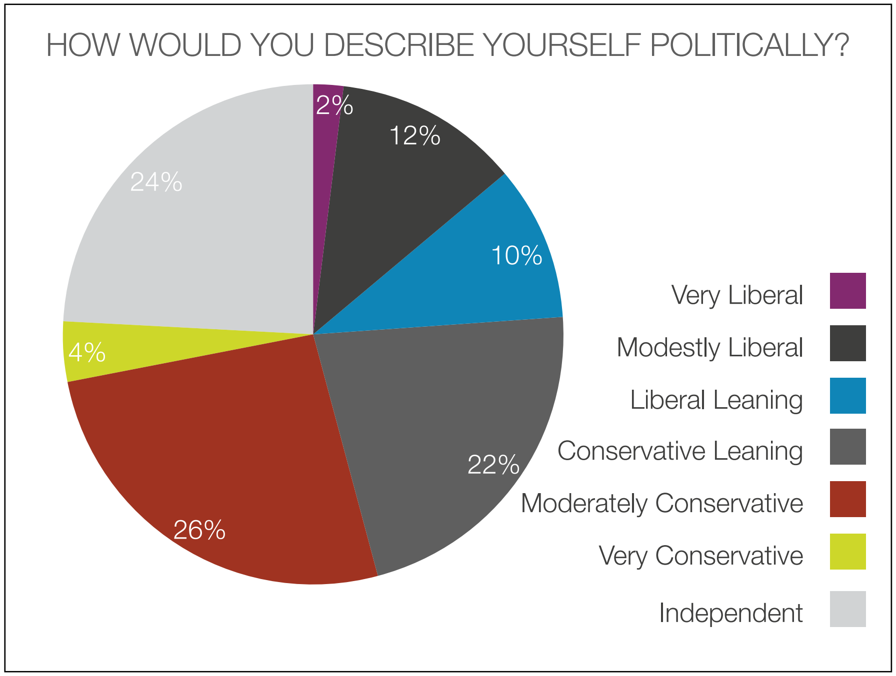

Figure 4.4.3 WMC Survey Participant's Self-Described Political Preference

The following figures show the participants' responses to a number of questions regarding their support and concerns for a biofuels industry in the region. Figure 4.4.4 shows the level of participants' support for a biofuels industry in the region. The graph shows that the majority of participants (86.2%) believe development of a biofuels industry in the Pacific Northwest would be good for the region, even though some (27.5%) had concerns.

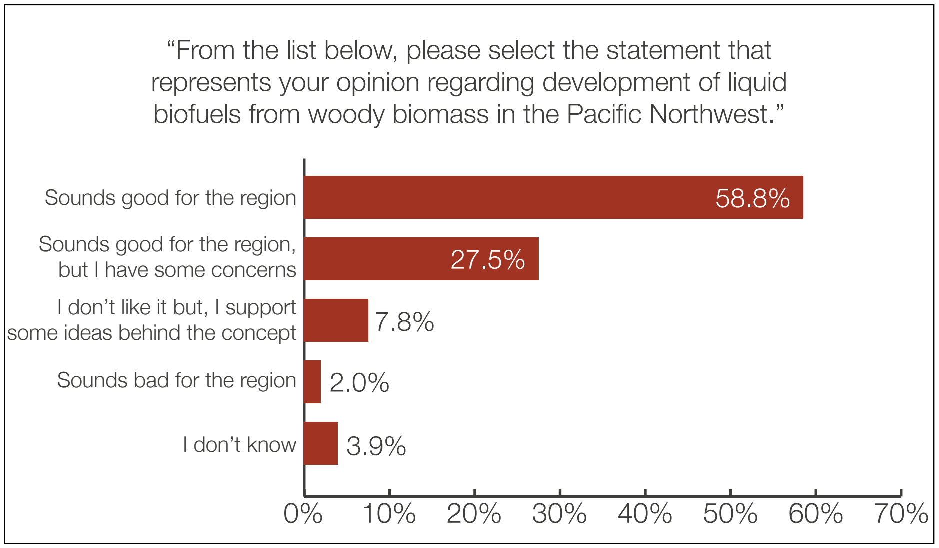

Figure 4.4.4 Participants' opinions regarding the development of liquid biofuels from woody biomass in the Pacific Northwest

Figure 4.4.5, shows participants' level of concern regarding multiple topics. From the items listed, the 'local economy' in their region, 'forest health in the Pacific Northwest,' and 'forest management practices on public lands in the Pacific Northwest' show the highest levels of concern.

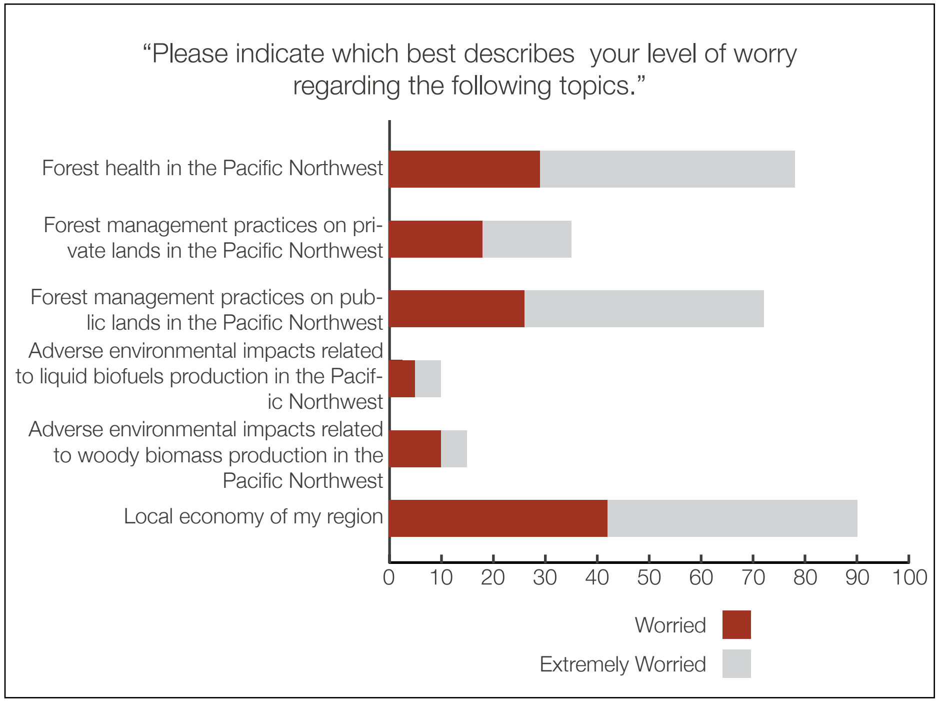

Figure 4.4.5 Participants' level of worry regarding several topics related to biofuels

We asked participants to indicate how much they agree with or disagree with a number of potential sources of woody biomass (Figure 4.4.6). There was significant agreement among the majority of participants that woody biomass from multiple forest management activities should be collected and used to produce bioenergy. Their sentiments suggest that biomass from areas treated for insect disease, restoration thinning and from logging operations should be considered.

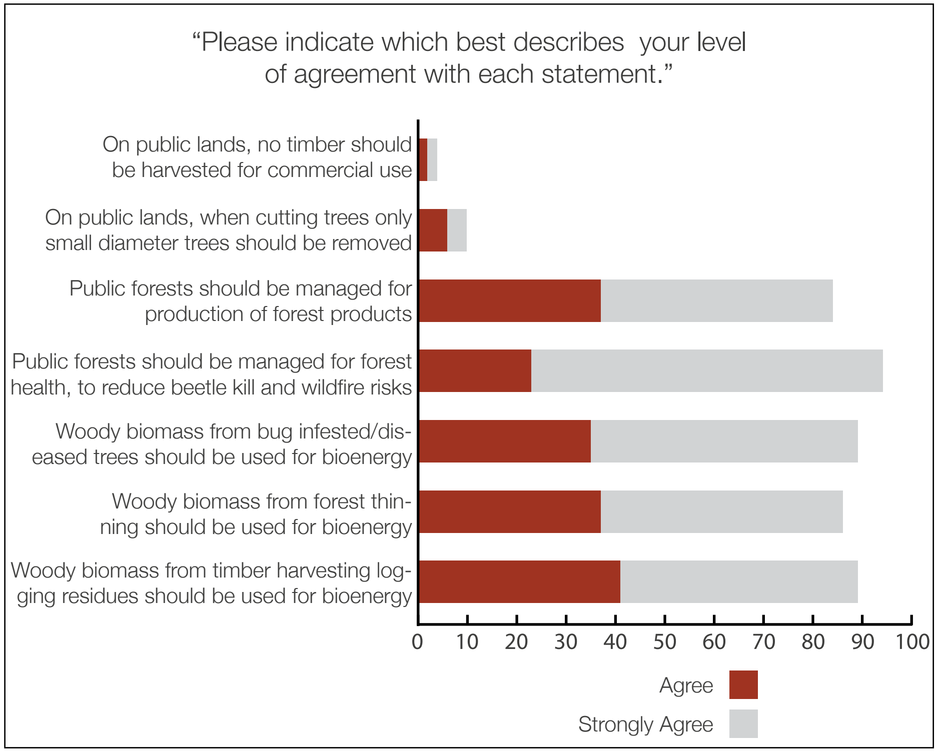

Figure 4.4.6 Participants' agreement with statements about sources of woody biomass

Participants were also asked to select the entities they trust to monitor forest management activities, especially as it relates to bioenergy production. Figure 4.4.7 shows responses that indicate significant trust in state foresters, independent 3rd party certifiers, university scientists and the US Forest Service.

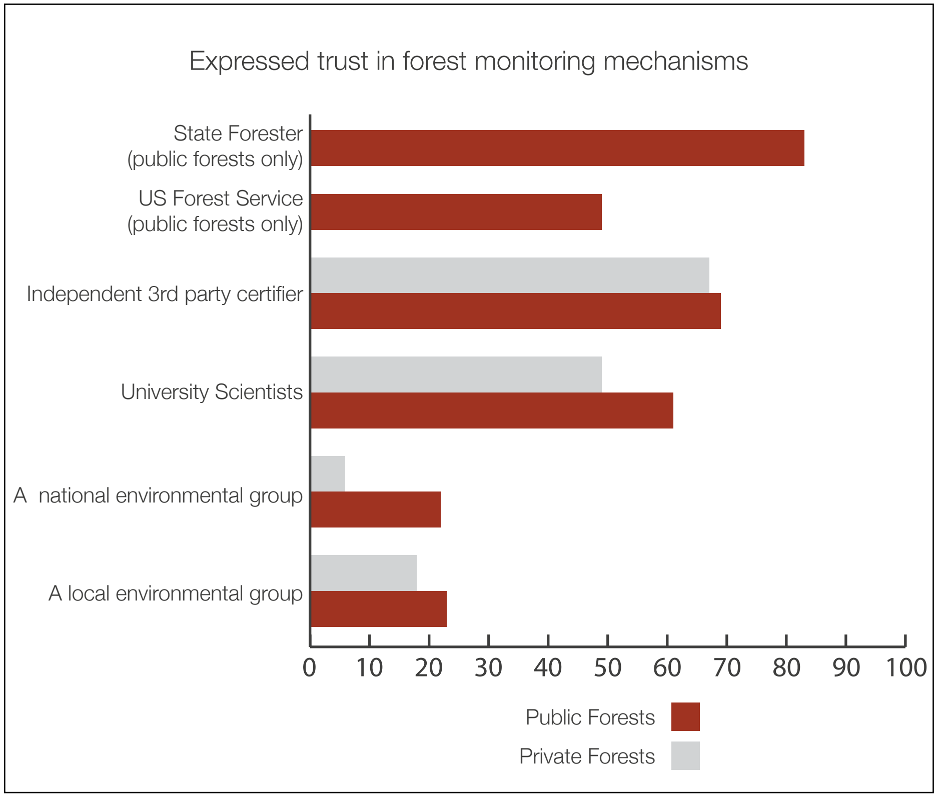

Figure 4.4.7 The expressed level of trust in groups of people potentially responsible for monitoring forests used as a potential source of woody biomass

The survey provided participants with the opportunity to discuss the potential benefits that might result from using woody biomass to create liquid biofuels. The word cloud in Figure 4.4.8 shows the words that participants used to describe benefits. The larger the word, the more often it was used. 'Forest health,' 'fire reduction,' and 'jobs' stand out as three benefits identified most often by participants.

4.4.2 K-12 Education Efforts in the WMC

The K-12 NARA Education group consists of faculty, staff and graduate students from the McCall Outdoor Science School (MOSS), staff from Facing the Future, Imagine Tomorrow representatives and supporting faculty from the University of Idaho and Washington State University. This group works on research as well as programming and curriculum projects that enhance energy literacy at all stages in education. Engagement opportunities are focused on the development of curriculum and on delivering teacher professional development. The research, outreach and planning that goes into the WMC reporting (by UI and WSU faculty and students) in 2012-2013 informs our education efforts the following year (2013-2014)

The K-12 education efforts also include in-service teacher professional development. For example, in the summer of 2013, MOSS hosted a workshop that one Montana teacher attended, the Fall 2013/Spring 2014 Imagine Tomorrow Competition Mentoring will target 15 teachers and 60 students from Montana, and the NARA Education Team presented workshops at the 2013 Montana Education Association (MEA) conference in October 17-19 2013. Also at the MEA conference, the NARA Education group recruited 15 teachers to work on our K-12 biofuels literacy project and they will receive $1000 each in support of their work. Finally, the 2013 Imagine Tomorrow Competition (funded by NARA) awarded 1st place to the Sentinel High School team from Missoula, Montana for the categories of 'Most Innovative' and 'Best in the Behavioral Challenge' categories. Their research focused on this question: How can we use popular media to influence behavior and encourage individuals to take personal responsibility to improve the environment? Read more about the NARA K-12 Education projects at: http://imagine.wsu.edu/past/2013/schools/sentinel.aspx

Figure 4.4.8 Benefits from using woody biomass for biofuels