WESTERN MONTANA CORRIDOR

Supplemental Information
Volume V

Northwest Advanced Renewables Alliance

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5.1.0 WHITE PAPER: RFS, RINs, AND NARA REGION IMPLICATIONS

Author: Stephen Wentz, Pennsylvania State University
Advised by Paul Smith, Pennsylvania State University

The emerging biofuels industry in the U.S. has the potential to produce sustainable alternatives to petroleum-based fuels, a development which would decrease dependence on foreign oil, increase national security, stimulate job growth, and improve the condition of the natural environment. Although there have been objections to biofuels by stakeholders in the petroleum industry, this is mostly due to the effects the growth in sustainable biofuels would have on the bottom lines of these petroleum firms. Biofuels has had the support of recent federal administrations and Congresses. This support has been manifested in the original Renewable Fuel Standard (RFS 1), enacted under the Energy Policy Act (EPAct) of 2005, and further expanded into RFS 2 under the Energy Independence and Security Act (EISA) of 2007 (EPA, 2013). RFS 2 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 four-state NARA region in the Pacific Northwestern United States, consisting of Idaho, Montana, Oregon, and Washington, and the stakeholders within the NARA community, must consider the policy implications of RFS on the NARA project. This document is an effort to educate these stakeholders on this topic in the hopes that value can be added to NARA with a greater understanding of federal renewable fuels policies. The first part of this white paper addresses some concerns of NARA stakeholders with respect to qualifying feedstock requirements under RFS, while the second part discusses RFS biofuels proposals and the Renewable Identification Number (RIN) system that the Environmental Protection Agency (EPA) intends to utilize to enforce RFS mandates. The report concludes with additional commentary on the dynamic nature of certain RFS policies and the potential effects they have on biofuels markets.

5.1.0.1 Feedstock Requirements Under RFS

The definition of renewable biomass under RFS 2 has direct implications for the NARA region with its woody biomass feedstock concentration. Woody biomass counts as renewable biomass provided that it comes from non-federal lands (including Indian tribal lands), forested or non-forested, where the forested lands are not ecologically sensitive, and where the non-forested lands are actively managed and have not been cleared since December 19, 2007. The EPA definitions below, excerpted from the March 26, 2010 Federal Register, are directly relative to the NARA region (EPA 2010).

Renewable biomass means each of the following (including any incidental, de minimis contaminants that are impractical to remove and are related to customary feedstock production and transport):

(1) Planted crops and crop residue harvested from existing agricultural land cleared or cultivated prior to December 19, 2007 and that was non-forested and either actively managed or fallow on December 19, 2007.

(2) Planted trees and tree residue from a tree plantation located on non-federal land (including land belonging to an Indian tribe or an
Indian individual that is held in trust by the U.S. or subject to a restriction against alienation imposed by the U.S.) that was cleared at any time prior to December 19, 2007 and actively managed on December 19, 2007.

(3) Slash and pre-commercial thinnings from non-federal forestland (including forestland belonging to an Indian tribe or an Indian individual, that are held in trust by the United States or subject to a restriction against alienation imposed by the United States) that is not ecologically sensitive forestland.

(4) Biomass (organic matter that is available on a renewable or recurring basis) obtained from the immediate vicinity of buildings and other areas regularly occupied by people, or of public infrastructure, in an area at risk of wildfire.

Slash is the residue, including treetops, branches, and bark, left on the ground after logging or accumulating as a result of a storm, fire, delimbing, or other similar disturbance.

Pre-commercial thinnings are trees, including unhealthy or diseased trees, primarily removed to reduce stocking to concentrate growth on more desirable, healthy trees, or other vegetative material that is removed to promote tree growth.

According to the above stipulations, beetle-kill trees from the NARA region qualify as renewable biomass under RFS 2, provided that they do not come from federal lands, which currently automatically disqualifies any biofuels feedstock, both foreign and domestic. (Schnepf et al 2012)

5.1.0.2 EPA Proposals for 2013 for Renewable Volume Obligations and RINs Under RFS

The 2013 EPA proposed volumes for biofuels production in the U.S. are listed below. Table 5.1.1 shows the EPA's proposed volume requirements for renewable fuels production while Table 5.1.2 illustrates the EPA's proposed percentage of renewable fuels as a ratio of renewable fuel production to non-renewable fuel production (EPA 2013). These proposals are open to the public and other stakeholders for comment for 45 days, after which the EPA will consider the feedback provided and finalize the 2013 mandates for biofuels production in the U.S. (Lane 2013). These renewable fuel categories are tiered, which means cellulosic biofuel and biomass based diesel count toward the total advanced biofuels requirements, and total advanced biofuels count toward the total renewable fuels requirements (EPA 2013). Companies that blend fuels for the retail market in the U.S. are obligated to meet the Renewable Volume Obligations (RVOs) for 2013 as shown in Table 5.1.2.

These RVOs are set annually by the EPA. In terms of the NARA project's biojet focus, jet fuel is classified as an "additional renewable fuel" under RFS and does not fall under the total "advanced biofuels" category, which means there is currently no specific volumetric requirement that must be met in terms of annual biojet production (DOD 2011).

Table 5.1.1. EPA proposed volumes of renewable fuels for 2013

Cellulosic biofuel	0.014 billion gal
Biomass-based diesel	1.28 billion gal
Advanced biofuel	2.75 billion gal
Renewable fuel	16.55 billion gal

Table 5.1.2. EPA proposed percentage standards for 2013 in terms of a ratio of renewable fuels to non-renewable fuels

Cellulosic biofuel	0.008%
Biomass-based diesel	1.12%
Total advanced biofuels	1.60%
Total renewable fuels	9.63%

5.1.0.3 Renewable Identification Numbers

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). An explanation of the characters in a RIN is illustrated in Figure 5.1.1. RINs are generated when the producer or importer of a qualifying biofuel submits an application to the EPA for review, and the EPA subsequently approves it. Currently there is a small producer/importer exemption for producers or importers of less than 10,000 annual gallons of renewable fuels. This exemption has been temporarily extended for up to three years to a less than 125,000 annual gallons level for producers, a change that is an effort to allow pilot and demonstration plants to further develop biofuels technologies (Schnepf et al 2012). RINs remain with the biofuel throughout the distribution channel until the biofuel is blended into the gasoline or diesel supply in the U.S. Blenders and exporters of transportation fuels in the U.S., as obligated parties under RFS , are then required to turn these RINs into the EPA to meet specific RVOs and show compliance with the RFS mandates.

5.1.0.4 RINs Codes

RIN = KYYYYCCCCFFFFFBBBBBRRDSSSSSSSSEEEEEEEE

Where:
K = code distinguishing RINs still assigned to a gallon from RINs already separated

YYYY = the calendar year of production or import

CCCC = the company ID

FFFFF = the company plant or facility ID

BBBBB = the batch number

RR = the biofuel energy equivalence value

D = the renewable fuel category

SSSSSSSS = the start number for this batch of biofuel

EEEEEEEE = the end number for this batch of biofuel

Figure 5.1.1. Renewable Identification Number (RIN) Codes Explanations

5.1.0.5 Equivalence Values

Under RFS1 equivalence values (EVs) were assigned to renewable fuels based on their specific categories with respect to their energy content relative to ethanol, but under RFS2 each category of renewable fuel has its own volumetric requirements; therefore EVs are no longer necessary to incentivize certain biofuels based on energy content (Schnepf et al 2012). EVs will still be utilized to meet the overall advanced biofuels or total renewable fuels requirements, but not within individual renewable fuels categories. EVs for select renewable fuel categories are listed in Table 5.1.3. At the EPA's discretion, additional EVs can be added, for instance as more feedstocks are classified as renewable under RFS regulations, while current EVs are subject to change. The EPA uses an energy content-based formula, shown in Figure 5.1.2, to determine equivalence values for any new qualifying renewable fuels (EPA 2010).

Table 5.1.3. Select equivalence values (EVs) of renewable fuels under RFS1 (Schnepf et al., 2012). Note: This EV was eliminated under RFS2.

Ethanol	1.0
Butanol	1.3
Biodiesel	1.5
Cellulosic ethanol[1]	2.5

Where:

EV = (R/0.972) * (EC/77,000)

EV = Equivalence Value for the renewable fuel, rounded to the nearest tenth

R = Renewable content of the renewable fuel

This is a measure of the portion of a renewable fuel that came from a renewable source, expressed as a percent, on an energy basis

EC = Energy content of the renewable fuel, in Btu per gallon (heating value)

Figure 5.1.2. Energy content-based equivalence value (EV) formula under RFS2 (EPA, 2010)

5.1.0.6 Waiver Credits

The EPA can authorize waiver credits if it is determined that volume requirements under RFS are not going to be met. Once a waiver credit is approved, the EPA makes them available to obligated parties that have not met their RIN requirements at a designated cost. An example of this is the cellulosic biofuels waiver credit, which was offered for purchase at $1.56 in 2010, $1.13 in 2011, and $0.78 in 2012 (Bracmort 2012). Currently cellulosic waiver credits are the only authorized waiver credits, but the EPA has waiver authority to include others in the future (EPA 2010). Waiver credits are only authorized for use in the year they are issued and cannot be banked for future use (Bracmort, 2012).

5.1.0.7 RIN Markets

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 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.

5.1.0.8 RIN Fraud and QAPs

The EPA is currently not fully enforcing the RIN requirements under RFS due to some fraudulent RINs appearing in the marketplace. The appearance of these fake RINs has temporarily jeopardized the integrity of RFS . Under the current RFS structure, purchasers of fraudulent RINs are liable to the EPA for fines, while still obligated to acquire the necessary RINs to meet their respective requirements, so "let the buyer beware." The EPA recently said that it was working on a voluntary Quality Assurance Program (QAP) that would serve as a legitimate defense for companies against RIN fraud (EPA 2013).

5.1.1 COMMENTARY

Many of the RFS and RIN topics discussed above must be continuously reexamined, as the fluid nature of the fledgling biofuels policies in the U.S. could turn an advantageous position into a disadvantageous one relatively quickly. The EPA continuously updates several “moving targets” under RFS, including Renewable Volume Obligations (RVOs) and equivalence values (EVs). RVOs are updated annually, while EV s can be changed as the EPA sees the necessity to update its policies. As new biofuels emerge, the EPA assigns EVs to determine their volumetric equivalents in the “total renewable fuels” and “total advanced biofuels” categories. This EV policy does not seem to have the same impact under RFS2 as it did under RFS1, as each biofuel now has its own distinct category with specific gallon for gallon RVOs, as opposed to ethanol equivalent values, nevertheless, the EVs will still be applied to the biofuels totals as stated above. These “moving targets” can influence which biofuels producers decide to make, and a company like Gevo, that potentially has the ability to switch between different platforms, could have a distinct competitive advantage in the biofuels field.

In terms of RIN markets, the demand for these biofuels identifiers will fluctuate based on a variety of market conditions, including changing biofuels supplies, the successes or failures of companies in meeting RVOs, and updated government policies. A biofuels RIN that is worth $2.50 today may be $5.00 or $0.50 six months or a year from now, and the organizations and stakeholders that stay abreast of these shifting markets can better position themselves in the rapidly changing biofuels industry. As the EPA’s voluntary Quality Assurance Program (QAP) materializes, RIN traders will gain confidence in these RIN markets knowing that they have a better chance of defending themselves against the penalties associated with counterfeit RINs.

5.1.2 SUMMARY

Although the RFS and its RIN tracking mechanisms are still currently in a debugging phase, and are not being fully enforced, a greater understanding of these policies and procedures will assist stakeholders in the NARA region with the future development of the biofuels industry in the Pacific Northwest. That being said, the dynamic nature of biofuels policies in the U.S. must be monitored, understood, and, when possible, leveraged into advantageous opportunities by NARA stakeholders. By staying abreast of these shifting biofuels policies, the NARA team will be better positioned moving forward with NARA project goals and objectives.

5.1.3 REFERENCES

Bracmort, K. 2012. Meeting the Renewable Fuel Standard (RFS) Mandate for Cellulosic Biofuels: Questions and Answers. Washington, D.C.: Congressional Research Service.

DOD. 2011. Opportunities for DOD Use of Alternative and Renewable Fuels: FY10 NDAA Section 334 Congressional Study. Washington, D.C.: Department of Defense.

EPA. 2010. 40 CFR Part 80 Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule. Washington, D.C.: Environmental Protection Agency.

EPA. 2013. Renewable Fuel Standard (RFS). Available at United States Environmental Protection Agency: http://www.epa.gov/otaq/fuels/renewablefuels/index.htm. Accessed 31 January 2013.

Lane, J. 2013. The 2013 Renewable Fuel Standard: Biofuels Digest's 10-Minute Guide. Available at BiofuelsDigest: http://www.biofuelsdigest.com/bdigest/2013/02/01/the-2013-renewable-fuelstandard-biofuels-digests-10-minute-guide/. Accessed 1 February 2013.

Schnepf, R., & Yacobucci, B. 2012. Renewable Fuel Standard (RFS): Overview and Issues. Washington, D.C.: Congressional Research Service.

Yacobucci, B. 2012. Analysis of Renewable Identification Numbers (RINs) in the Renewable Fuel Standard (RFS). Washington, D.C.: Congressional Research Service.

5.2.0 MUNICIPAL SOLID WASTE ANALYSIS

The Municipal Solid Waste Group has completed a preliminary inventory that assesses the biomass within the municipal solid waste (MSW) and construction and demolition (C&D) supply chain throughout the entire NARA region, which includes the WMC. Research focus is placed upon developing an overall inventory of the woody construction debris biomass in the Northwest (especially NARA communities), developing strategies to increase the recovery of this material, establishing QC/product specifications, and identifying where these materials fit within the wood utilization supply chain.

5.2.1 MSW/C&D WOODY BIOMASS INVENTORY IN NARA REGION

A preliminary MSW and wood waste assessment was performed to determine quantities of such materials for each state within the NARA region; results are presented in Table 5.2.1. Total United States waste information was acquired through an EPA report. Montana, Oregon, and Washington waste information was obtained through state databases or from state employees (references included in figures). So far, partial Idaho information has been acquired at the county level; not all counties have yet been contacted. Figure 5.2.1 illustrates MSW distribution by county and by landfill within the NARA region. MSW includes all household and commercial waste that is not hazardous in nature. Depending on the landfill or transfer station, recyclable items such as plastic, metal, glass, and wood are sorted and separated from non-recyclable MSW.

Wood waste can be disposed of in MSW landfills or reused/recycled at material recycling facilities (MRFs) and be used to create products such as reclaimed timber, composites, compost, or hogged fuel for energy recovery. A preliminary list of MRFs was originally created using state databases and Internet searches regarding wood recycling. In all, a list of 53 MRFs that recycle C&D wood waste was compiled for the 4-state NARA region. Quick-fact information regarding the MRFs is represented in Table 5.2.2. Wood waste quantities collected from MRFs were obtained in units such as board foot, C&D ton, cubic yard of loose scrap wood, and cubic yard of shredded wood; conversion factors can be viewed in Table 5.2.3. A list of MRFs and their pertinent data is represented in Table 5.2.4, and recycled wood waste distribution per county and MRF can be viewed in figure 5.2.2. In total thus far, a sum of 646,729 tons of recycled wood waste has been accounted for by MRFs within the NARA region.

Table 5.2.1. A preliminary MSW and wood waste assessment for each state within the NARA region

	Generated Municipal Solid Waste		Generated Wood Waste	
	Tons/year	lbs/Person/Day	Tons/Year	lbs/Person/Day
United States [1]	249,860,000	4.43	15,880,000	0.28
Idaho [2]	Not yet determined			
Montana [3]	1,323,343	7.26	Not yet determined	
Oregon [4]	4,740,561	6.71	376,798	0.53
Washington [5]	8,860,856	7.17	1,203,074	0.98

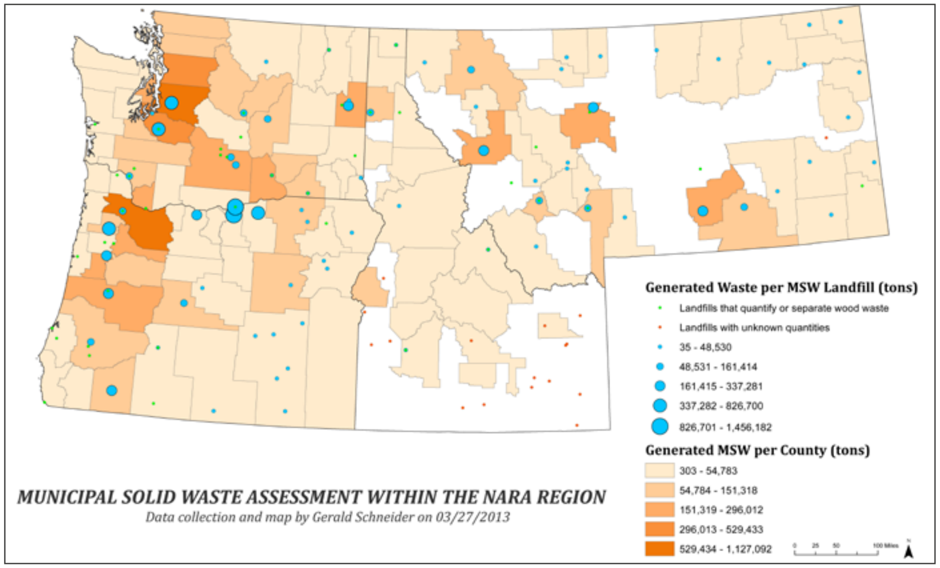

Figure 5.2.1. MSW distribution by county and landfill within the NARA region

Table 5.2.2. Quick facts regarding MRF research within the NARA region

MRF DATA PER STATE					
State	Total Known MRFs	Total MRFS with Data Unknown	Total MRFs with Volume Data Unknown	Estimated MRF Wood Quantities (tons/year)	Recycled Wood Majority Market
Idaho	4	0	0	44,979	Reclaim Timber
Montana	7	1	2	6,812	Reclaim Timber
Oregon	18	3	6	100,280	Hog Fuel
Washington	24	2	8	494,658	Hog Fuel
Total	53	6	16	646,729	Hog Fuel

Table 5.2.3. Table of conversion factors that were used during the wood waste assessment

WOOD VOLUME CONVERSION FACTORS		
Volume Type	Conversion	Source
Board Feet [BF]	BF * [0.008 Ton/1 BF]	Cunningham, Kyle. Converting Board Feet to Tons. University of Arkansas Division of Agriculture. http://www.arnatural.org/News/Timber_Report/Converting_Weight_Board_Feet.pdf Accessed 4/11/2013
Clean Wood within C/D Waste	C/D Tons * [0.115 Clean Wood/CD ton]	2007 Massachusetts Construction and Demolition Debris Industry Study, Final Report. DSM Environmental Services, Inc., 5/16/2008. www.mass.gov/dep/recycle/reduce/07cdstdy.pdf Accessed 01/04/2013
Cubic Yard [CY]: Shredded Wood Chips	CY * [500 lbs/1 CY] * [1 ton/2000 lbs	Standard Volume-to-Weight Conversion Factors. U.S. Environmental Protection Agency. http://www.epa.gov/smm/wastewise/pubs/conversions.pdf Accessed 8/22/2012
Cubic Yard [CY]: Wood Scrap, Loose	CY * [329.5 lbs/1 CY] * [1 ton/2000 lbs]	Standard Volume-to-Weight Conversion Factors. U.S. Environmental Protection Agency. http://www.epa.gov/smm/wastewise/pubs/conversions.pdf Accessed 8/22/2012

Table 5.2.4. List of MRFs within NARA region listed by state

IDAHO					
MRF	Location	Volume	Reach	Tipping Fees	Market
Building Material Thrift Store	Hailey, ID	25,000 tons Building Materials per year	No Data	No Data	Timber/Lumber Reuse
Cannon Hill Industries	Post Falls, ID Spokane, WA	ID: 32,000 green tons WA: 15,000 green tons	100 miles	No Data	Hog Fuel sent to Clearwater Paper Corporation
Ross Lumber	Shoshone, ID	600 tons/year	Supply: Through U.S. Distribution: Pacific Northwest	No Data	Timber/Lumber Reuse
Trestlewood	Blackfoot, ID	9504 tons/year	Supply: Western U.S. Distribution: Throughout U.S.	Bid Based	Reclaim Timber

MONTANA					
MRF	Location	Volume	Reach	Tipping Fees	Market
Big Timberworks	Gallatin Way, MT	35 tons/year of wood waste residue	Throughout U.S.	Bid Based	Reclaim Timber
Eko Compost	Missoula, MT	No Data	Supply: Bonner, ID No Distribution	$1/bag $7/pickup or small trailer $15/ large trailer $50/semi load No charge for pre-chipped	Compost Firewood
Heritage Timber	Bonner, MT	2800 tons stored	Supply: 250 miles Distribution: Pacific Northwest	No Data	Reclaim Timber
Home ReSource	Missoula, MT	1977 tons/year	Eastern Montana and Idaho	All is donated Tax Class 501C3	Mostly Reuse Small Pieces sent to Eko Compost
Johnson Brothers Recycle	Missoula, MT	No Data	No Data	No Data	No Data
Montana Reclaimed Lumber Company	Gallatin Gateway, MT	16,000 tons stored	No Data	Bid Based	Reclaim Timber
Resource Site Services	Bozeman, MT	2000 tons/year	100 miles service reach, no distribution	Bid based	Mobile Wood and Construction Material Grinding

5.2.2 INVENTORY OF NARA COMMUNITIES

To date, a review of our research has indicated that separated landfill wood waste data within the WMC is predominantly categorized into three categories: inert waste, C&D waste, and wood waste (a phrase that usually refers to clean wood). Ascertaining wood waste quantities within inert waste totals is difficult and no modeling technique has currently been determined. Wood waste derived from C&D waste on average can be quantified as 31% of total C&D waste, and 34% within C&D wood waste is untreated, unpainted, or comes from pallets. Table 5.2.5 indicates MSW, C&D, and wood waste totals from counties within the WMC. There are currently five known counties within the WMC that quantify clean wood waste, and there are four known counties that quantify C&D waste. In summary, 8,456 tons of usable C&D wood waste and 15,413 tons of clean wood waste were collected by participating counties within the WMC, creating a total of 24,639.5 tons of estimated wood waste a year. Figure 5.2.2 is an updated map representing known landfills that separate wood within the WMC. Further maps will indicate MSW, C&D, and wood waste quantities per county.

Table 5.2.5. Wood waste and C&D clean wood waste totals for counties withing the WMC.

State	County	Population (2011)	MSW (tons)	C&D (tons)	C&D Wood* (tons)	Wood (tons)
ID	Bonner[1]	40,808	33,330	0	0	2,500
	Boundary[2]	10,804	4,500	0	0	318
	Kootenai[3]	141,132	121,171	0	0	10,899
	Lemhi[4]	7,967	9,048	644	74.06	0
	Shoshone[5]	12,672	5,691	0	0	1,390
MT	Gallatin[6]	91,377	108,647.37**	6,807.3	782.84	306
	Silver Bow[7]	34,383	75,679**	13,060	1,501.90	0
WA	Spokane[8]	473,761	314,355.91	59,719.12	6,867.70	0
TOTAL					9,226.50	15,413
					24,639.50	
*Clean C&D Wood figured as 11.5% of C&D total.						
**MSW quantities provided by State of Montana[9]						

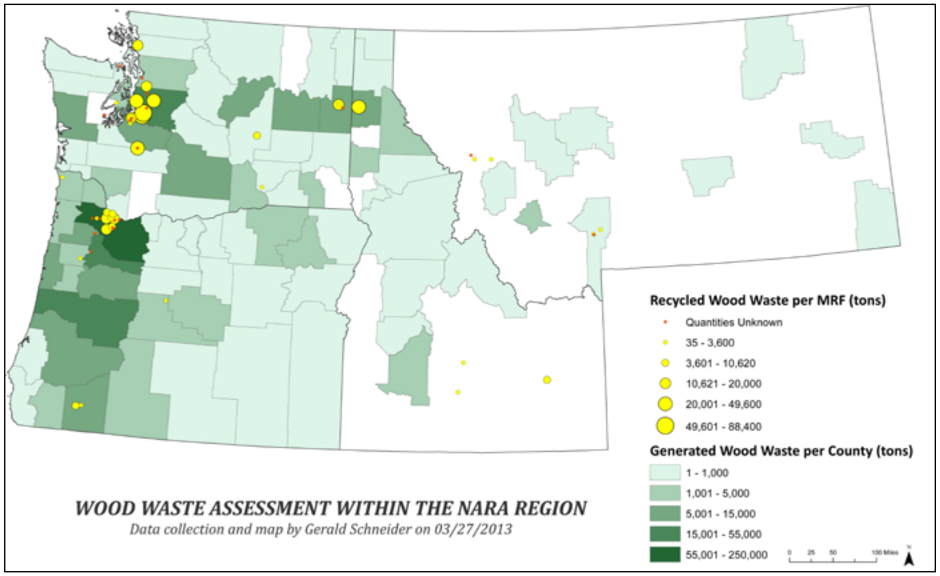

Figure 5.2.2. Wood waste distribution by county and MRF within the NARA region

Figure 5.2.3 is a map that represents MRFs within the WMC. Wood waste and C&D wood waste have been identified with two separate shades of green to show the known wood quantities from the estimated wood quantities (C&D). MRF research within the WMC is nearly complete; further information regarding two MRFs within the wmC is still anticipated. There are currently eleven known MRFs within the WMC, which include building salvage stores, reclaimed timber mills, wood grinding service companies, and general wood recyclers. Specific years for collected data may vary. Reclaimed timber mills collected a total of 2,824 tons of wood a year. Wood recyclers collected 6,477 tons of wood a year. Building salvage stores compiled 5,375 of C&D wood waste. In total, WMC MRFs compiled 15,413 tons of wood waste a year. This total, however, may include wood that is utilized in other markets.

Our research indicates that the majority of C&D wood waste accrues in areas of higher population densities, most notably Seattle, WA and Portland, OR. Figure 5.2.4 represents the distribution of wood waste per county and MRF within the western NARA region. Of the 53 MRFs in the 4-state NARA region, 41 MRFs are located east of the Cascade mountains. However, out of the 646,729 total tons of the MRF recycled wood waste quantified thus far, 546,832 tons (83%) derive from the western 4-state NARA region (i.e. west of the Cascades). Recycled wood waste in this region is primarily used for energy co-generation in the form of hogged fuel; other uses include composites, compost, and pulp.

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1 Bonner County Solid Waste Department. Received via telephone questionnaire: 8/22/12
2 Boundary County Solid Waste Department. Received via telephone questionnaire: 8/22/12
3 2011 Solid Waste Analysis. Kootenai County Solid Waste Department. Coeur D'Alene, ID. Provided by Kootenai County Solid Waste Department: 8/22/12
4 Lemhi County Solid Waste Management. Received via telephone questionnaire: 8/22/12
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7 Butte Silver Bow Rocker Landfill. Received via telephone questionnaire: 8/02/12
8 CountyTotals11.xcl. State of Washington Department of Ecology. http://www.ecy.wa.gov/programs/swfa/solidwastedata/ Accessed 1/07/13
9 MT—LF-tonnage-reg.xcl. State of Montana Department of Environmental Quality. Received 8/14/12

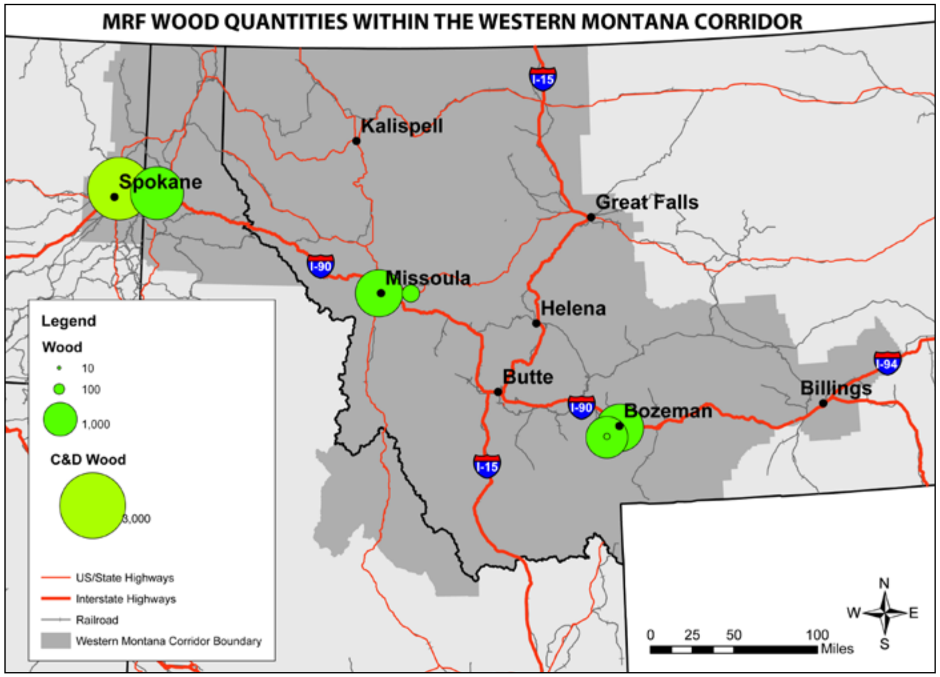

Figure 5.2.3. Wood waste distribution per MRF within Western Montana Corridor

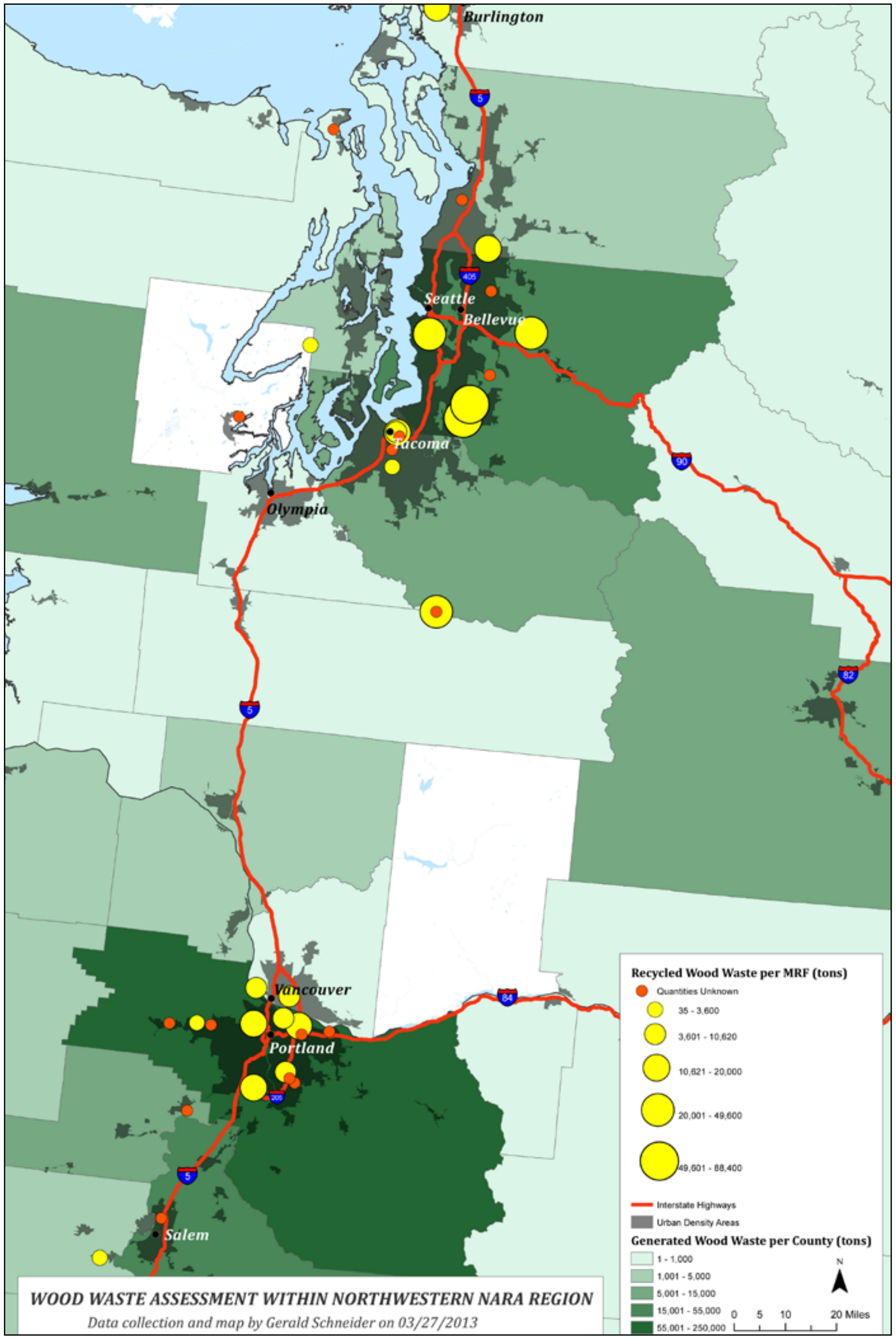

Figure 5.2.4. Wood waste distribution near urban density areas within western NARA region

5.2.3 NEXT STEPS: IDENTIFYING RECOVERY STRATEGIES

A supply Chain management (SCM) network was established and is essential for determining the viability of wood waste as a biofuel feedstock. SCM includes four aspects: sourcing, logistics, operations, and marketing. Sources of wood waste include MSW, industrial waste, construction and demolition (C&d) waste, and land clearing debris. Wood waste is often collected and separated at MRFs, landfills, and transfer stations; transportation methods include municipal self-haul, residential/commercial route trucks, and commercial drop-boxes. Although landfills are known for burying waste, there are many landfills that separate recyclable materials in order to prolong the lifespan of the landfill. Recyclable materials, such as wood waste, are often subcontracted or sold to MRFs for further recycling. MRFs recycle wood waste and produce products such as reclaimed timber, engineered wood, compost, paper pulp, soil amendment, and hogged fuel for energy recovery. Figure 5.2.5 represents a supply chain flow chart of the wood waste supply chain.

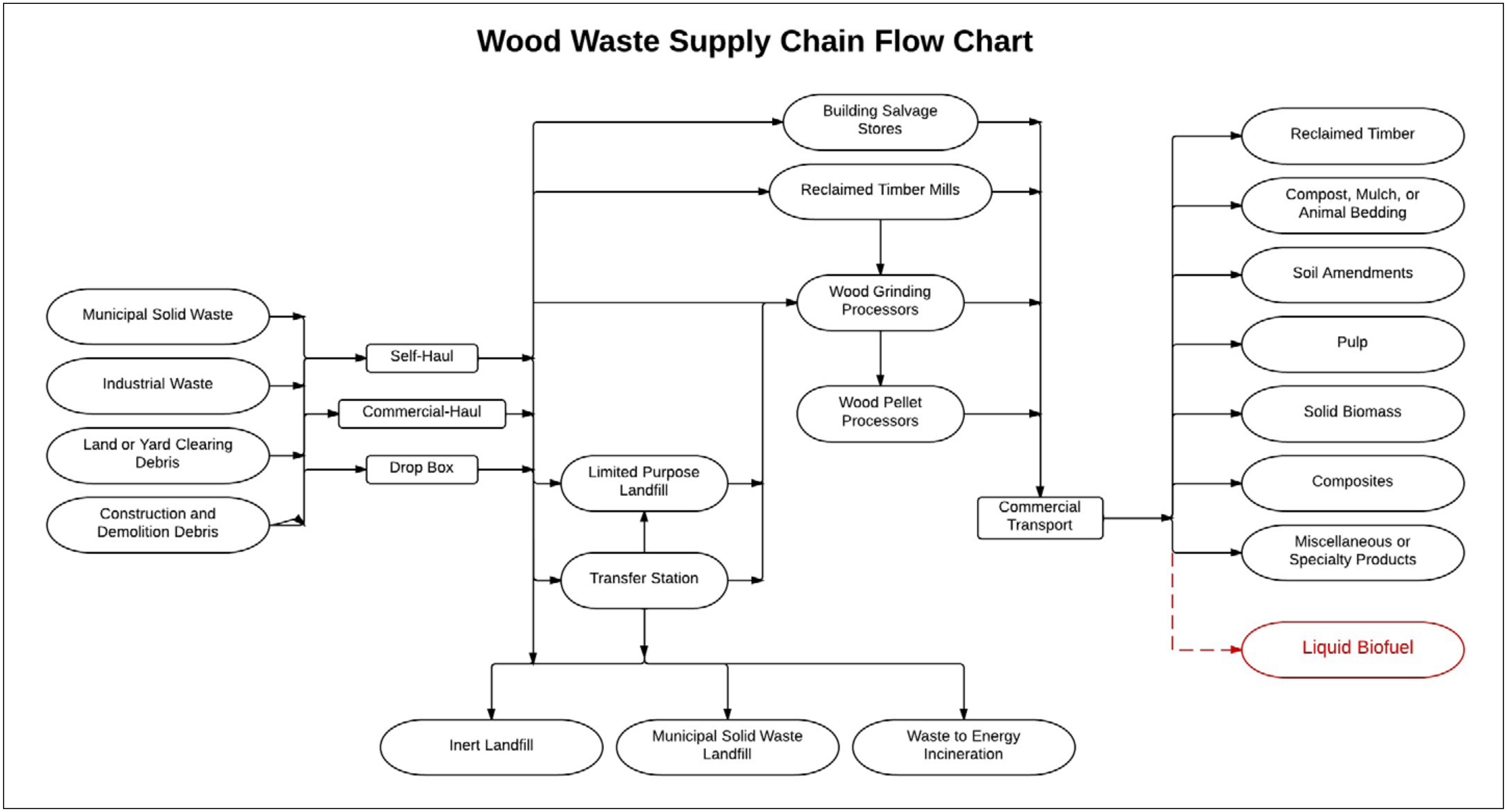

Figure 5.2.5. Illustrated flowchart of the wood waste supply chain

5.2.4 RECOMMENDATIONS/CONCLUSIONS

We are continuing to compile wood inventories within the C&D and MSW streams in the 4 NARA states (ID, MT, OR and WA) and several communities within the 4-state region. We are using ArcGIS to map the wood waste locations, and we are developing databases that can be incorporated into the final 4-state NARA regional assessment study. We are developing empirical models to predict the waste wood inventories in communities that do not have sufficient data.

5.2.5 REFERENCES

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5.3.0 STRATEGIC FEEDSTOCK PRODUCTION ANALYSIS FOR WMC

AUTHORS

Andrew Bourque
Richard Shuren
Brian Stanton
John Turland

GreenWood Resources, Inc.
1500 SW First Avenue
Portland, OR 97201

ACRONYMS AND SYMBOLS

1. AFRI: Agriculture and Food Research Initiative
2. DBH: Diameter at breast-height
3. DxM: P. deltoides x P. maximowiczii
4. DxN: P. deltoides x P. nigra
5. DxT: P. deltoides x P. trichocarpa
6. Dx(TD): P. deltoides x (P. trichocarpa x P. deltoides)
7. NARA: Northwest Advanced Renewables Alliance
8. NC: North Central region
9. NxM: P. nigra x P. maximowiczii
10. NxT: P. nigra x P. trichocarpa
11. PNW: Pacific Northwest region
12. TxD: P. trichocarpa x P. deltoides
13. (TD)xD: (P. trichocarpa x P. deltoides) x P. deltoides
14. TxN: P. trichocarpa x P. nigra

5.3.1 EXECUTIVE SUMMARY

GreenWood Resources studied the opportunity for poplar biomass plantations to supplement the supply of biomass originating as logging and thinning residues from coniferous stands in western Montana. Approximately 40,000 acres of agricultural and pastoral ground with annual precipitation rates of 25 to 40 inches were identified within 75 miles of potential refinery locations in Columbia Falls and Missoula. Silvicultural prescriptions and mean annual biomass increments (MAI) were projected for plantations stocked at 1,450 stems per acre and managed for five consecutive four-year coppice cycles following an initial two-year planted cycle. MAI projections varied between 2.8 and 4.9 bone dry tons per acre per year dependent on site quality and whether irrigation is applied. (MAI projections as well as varietal selections were based on a replicated varietal trial managed by GreenWood Resources and Flathead Valley Community College at Kalispell.) The economics of the opportunity were modeled for four scenarios defined as combinations of site quality and management intensity. The base case scenario - 10,000 acre development on sites of reasonable site quality and managed with intensive cultivation without irrigation – showed a break even price is $115 per bone dry ton. This pricing is higher than longstanding poplar programs in the Pacific Northwest, a consequence the region's limited precipitation and modest growth rates; irrigation will be required on most sites. However, the more appropriate pricing level is the weighted average price refineries will pay when their biomass supply originates as logging residuals blended with the plantation supply. While the plantation component may be the higher-cost one, it represents an indispensable constituent as a strategic foundation: Dedicated biomass plantations will reduce supply and pricing uncertainties associated with the inevitable cyclicality in the housing market that drives the availability of residuals remaining after trees are cut and processed for sawlogs. In order for NARA refineries to secure requisite financing, their feedstock supply portfolios may require purpose-grown energy plantations as a necessary addition to logging residuals.

5.3.2 INTRODUCTION AND BACKGROUND

5.3.2.1 History of Poplar Plantation Development

Planting poplar in the Pacific Northwest began in 1893 when the Willamette Pulp and Paper Company established 1,000 acres of black cottonwood (P. trichocarpa) plantations in the vicinity of West Linn, Oregon over a twenty-year period, reportedly the first artificial forest regeneration program in the United States (Priaulx 1952). Testing of hybrid varieties of poplar was then initiated in Washington in 1938 and 1939 by the U. S. Forest Service; a second effort of hybrid testing by Crown Zellerbach Corporation followed in 1947 (Beeman 1947). More recently through the 1980s and 1990s, the establishment of industrial poplar plantations in the Pacific Northwest repeatedly occurred as a strategic response to constraints in the regional supply of hardwood fiber for premium grades of communication papers. Five pulp and paper companies with significant investments in the Pacific Northwest undertook the development of these operations that are now recognized as the forerunners of today's poplar bioenergy plantation industry.

The recent history of the Pacific Northwest's poplar industry can be looked at as having a developmental period during 1984 – 1999 followed by a second period during 2000 – 2007 that saw a divestiture of assets and their reorganizations into a new ownership structure. The developmental period began as an effort to forestall forecasted shortages in the region's sole commercial hardwood species, red alder (Alnus rubra) through the establishment of poplar plantations as a replacement supply of short fibers (i.e. less than a millimeter in length). In 1982- 1983, Crown Zellerbach Corporation began planting hybrid poplar in the lower Columbia River valley near Clatskanie, Oregon and in the mid-Columbia River basin near Boardman, Oregon (Huddy et al.1983). Ultimately, James River Corporation acquired Crown Zellerbach's paper division and expanded the Clatskanie plantation to 11,000 acres. Shortly thereafter, Boise Cascade and Potlatch Corporations took the lead from James River in the mid-Columbia River basin, independently establishing a combined total of 36,000 irrigated plantation acres in the areas around Boardman, Oregon and Wallula, Washington. By the mid-1990s, MacMillan Bloedel had added 7,900 plantation acres in the Nooksack, Skagit, Snohomish, and Snoqualmie River valleys of northwest Washington and in British Columbia's Fraser River Valley and Vancouver Island.

Under James River's ownership from 1991 through 2000, the Clatskanie plantation produced approximately 30,000 dry tons annually for the refiner-ground wood operation at its Wauna, Oregon mill for the manufacture of highbright specialty newsprint. Boise Cascade's goal for its poplar program was to provide the entirety of the hardwood fiber required for the production of uncoated free sheet at the company's Wallula, Washington mill. Planting began in 1991 and the program harvested up to 100,000 dry tons annually beginning in 1997. Today, Boise Cascade manages approximately 9,000 acres strategically located within 20 miles of its Wallula mill. The Potlatch program started in 1994 as a response to declining wood flow from national forests and the need to increase fiber self-sufficiency at the Lewiston, Idaho mill. A 17,000 acre plantation at Boardman, Oregon was sized to annually produce 170,000 dry wood tons to meet 25-30% of the fiber requirements of the Kraft pulp operation for paperboard manufacturing. However in 1999, the company shifted its focus to the higher value saw log market with residual chips being sold to area pulp and paper mills. Finally, the Macmillan Bloedel poplar program spun off its poplar operations along with mills at Powell River and Port Alberni, British Columbia in 1998 in the formation of Pacifica Papers Inc. and later NorskeCanada. Ultimately the majority of the poplar estate was acquired by Catalyst Paper Corporation that harvested the stands as they matured, but did not replant in view of continuing low market prices for pulpwood.

The second period encompassing 2001 through 2007 was a time of active acquisition and consolidation in the poplar plantation industry orchestrated by GreenWood Resources. In 2001, the Clatskanie plantation was acquired by a timber investment organization under GreenWood's management, and production shifted to saw logs to increase the holding's profitability. Then in 2004, Boise Cascade sold approximately 8,800 acres of its poplar plantation to a second GreenWood investment fund as part of a larger sale of its paper and wood-products businesses to Madison Dearborn Partners. Lastly in 2007, GreenWood Resources acquired the entirety of the Potlatch's poplar operation and quickly consolidated it with the two aforementioned poplar funds into a single entity, the GreenWood Tree Farm Fund (GTFF). Today the fund owns approximately 30,000 plantation acres, a saw mill, planer mill, and dry kilns with the capacity of milling and drying 80 million board feet per year. A veneer mill was added in 2013 by Columbia Forest Products as an integrated manufacturing line though independent of GTFF. None of the former Macmillan Bloedel poplar lands were incorporated into GTFF.

5.3.2.2 Pulping Aspects of Poplar

Poplar has been frequently pulped using the thermo-mechanical process in making a wide range of lightweight, coated and uncoated grades of specialty newsprint. The species is well suited to the mechanical pulping process where its comparatively low wood density conserves energy during chip refining. Additionally, poplar's characteristic bright wood is preserved in mechanical pulps with minimal hydrogen peroxide bleaching (Johal and Hatton 1997). The chemical process has also been used in pulping poplar where the short and relatively wide, thin-walled fibers have proven to be ideally suited for the manufacture of high quality bond paper grades. These chemical fibers are low in coarseness and collapse easily during sheet formation with longer softwood fibers resulting in a smooth, dense formation with few surface voids, superior opacity, and good print retention.

A frequently voiced concern in chemical pulping of poplar is that its low wood density reduces digesting efficiency, yielding less pulp per unit of digester volume. Yet, Rapid Impregnation, Short Time Kraft pulping studies (RIST) at the State University of New York have documented that the greater porosity of poplar wood can be taken advantage of in managing digester operations to produce a higher amount of pulp per unit time compared with hardwoods of higher wood density (Francis et al. 2006). It remains to be determined whether converting poplar biomass to liquid fuels will similarly benefit from the porosity relationship.

5.3.2.3 Poplar as an Energy Feedstock

The advantage of short rotation, intensive culture forestry, originally envisioned as a novel source of pulping fibers nearly 40 years ago, has been vital to the development of the Pacific Northwest's poplar plantation industry (Ribe 1974). These advantages included: (1) High volume fiber production on a comparatively small land area, (2) Early amortization of site preparation, planting, cultivation and cropping costs, (3) Increased uniformity in wood and fiber properties with resultant increases in processing efficiencies, (4) Mechanization of farming practices to reduce labor costs, and (5) Lowered establishment costs through coppice regeneration. Today, hybrid poplar is considered to be one of the most promising energy crops for the renewable energy industry because of many of these same benefits (De La Torre Ugarte et al. 2003, Huang et al. 2009). And the realization of a poplar bioenergy industry should prove impactful to rural communities as its economic contribution may exceed some traditional agriculture ventures (Lazarus et al. 2011). The magnitude of the impact is expected to be dependent upon the capacity of power generating facilities and likely bio-refineries too (Gasol et al. 2009).

The specific case for large scale hybrid poplar energy farms is therefore often made in terms of: (1) Feedstock production, (2) Energy conversion, and (3) Environmental impacts. It is notable that within each of these three considerations, important varietal effects have been documented that can be exploited to further the prominence of the poplar bioenergy model.

Production - Hybrid poplar is the fastest growing tree species within the temperate zone with growth rates approximating five to eight dry tons per acre per year achieved on four-to-eight year pulpwood rotations (Stanton et al. 2002).

Moreover, when regenerated by coppice, productivity increases between the planted stage and subsequent coppice stages, with increases of up to 33% reported on good quality sites (Paris et al. 2011). The length of the coppice stage is equally important with growth rates observed over a four year coppice cycle exceeding those during a two year one (Guidi et al. 2009). Biomass quality is correspondingly affected by the length of the coppice cycle with higher proportions of cellulose and lowered lignin proportions characterizing longer cycles. To improve biomass production by varietal selection, poplar breeding efforts target genotypes that can withstand repeated coppicing with high stool survival and a favorable distribution of stump sprouts to maximize harvesting efficiency (Al Afas et al. 2008).

Conversion - Poplar wood has been successfully converted to liquid fuels using both biochemical and thermo-chemical methods (Lu et al. 2009, Jones et al. 2009) In the biochemical process, steam explosion, hot water extraction and exposure to low-concentrated acids are often used in pretreating poplar wood to make the cellulose more accessible to hydrolytic enzymes (Lu et al. 2009).

Poplar genotypes composed of proportionately higher sugar and lower lignin contents are desired for biochemical conversion (Luo et al. 2002). Varietal selection also targets genotypes characterized by amorphous cellulose crystallinity and high acetyl contents to effect high rates of sugar release upon hydrolysis (Laureano-Perez et al. 2006). The cellulose component of biomass is critical though and varies among poplar varieties by seven to 15 percentage points (Dinus 2001). The other two major biomass constituents, hemicellulose and lignin, do not seem to display as much variance and selection opportunities may not be as good. For example, the range in glucose and xylose content among 51 hybrid poplar clones was 48 to 53% and 17 to 20% of sample dry weight, respectively (GreenWood Resources, unpublished data). Sannigrahi et al. (2010) reported that a fixed sample of clonal varieties varied in cellulose content from 42 to 49% of dry weight, 17 to 22% in hemicellulose, but 21 to 29% in lignin. Francis et al. (2006) reported a similar range for a fixed varietal sample with the respective variations in cellulose, hemicellulose, and lignin as 44 to 50%, 17 to 21%, and 18 to 23%. Though selection opportunities for lignin content may or may not be limiting, the opportunity to base selection on the syringyl-toguaiacyl monolignol ratio should be better, and likely more consequential (Studer et al. 2011). To illustrate, data from GreenWood Resources indicates substantial variation in the monolignol ratio combined with high clonal repeatabilities: The range in the syringyl-to-guaiacyl ratio was 1.26 – 2.06, 1.31 – 2.06, 1.30 – 2.18, and 1.53 – 2.32 for its 1994, 1996, 1999, and 2003 breeding populations, respectively. Clonal repeatabilities are also substantial at 0.79, 0.77, 0.70, and 0.79 for the respective populations. Higher proportions of the syringyl monolignol form are generally indicative of heightened rates of sugar release.

The thermo-chemical method has also been used to convert hybrid poplar to pyrolysis oils by combustion of the wood at high temperatures in the absence of oxygen (Jones et al. 2009). The resultant gases are condensed to pyrolysis oils that are hydrotreated for cracking and distillation to gasoline and diesel fuels. Genotypes high in lignin may be well suited for combustion or fast pyrolysis due to elevated calorific content. Those with reduced wood concentrations of alkaline cations may also be preferred for the efficiency of the pretreatment step using dilute acids (Scott et al. 2000). But most of all, poplar varietal selection emphasizes specific gravity to increase biomass. The upper bound of poplar wood specific gravity approximates .400 (Robison et al. 2006).

Environmental - The net effect of poplar cropping systems on greenhouse gas emissions compares favorably to those of other cellulosic crops owing to their less frequent tillage and cutting cycles, with greenhouse gas sinks in excess of 200 g CO2e-C per square meter per year (Adler et al. 2007). Relative to petroleum derived fuels, liquid fuels production from European hybrid poplar plantations has been modeled to reduce contributions to global warming by 62%, although the location of the plantations and the intensity of the production practices strongly affect the outcome of the life cycle analyses (Gonzalez-Garcia et al. 2009). Rafaschieri et al. (1999) similarly report that, of all agricultural production factors that bear upon life cycle analyses for electrical power generation from poplar feedstock, pesticide and fertilizer usage are the weightiest ones. Soil carbon sequestration by poplar bioenergy cropping systems is a second environmental factor of note, although the dynamics are not well understood (Garten et al. 2011). The net amount of sequestered carbon reported for one poplar study in the southeastern United States ranged from five to 11 dry tons per acre after five years (Dowell et al. 2009). Increases of 68% in soil carbon over continuous rotations have been projected for low organic matter soils. Conceivably, clonal variation in biomass partitioning and the rate of root decomposition can be exploited to improve sequestration rates (Garten et al. 2011).

It has been known for some time that poplars emit significant quantities of isoprene, a volatile organic compound that potentially affects ozone concentrations (Isebrands et al.1999). Accordingly, as plantations of hybrid poplar become more commonplace as sources of cellulose for transportation biofuels they could influence regional air quality. Here again, varietal selection maybe important in mitigating emissions: Eller et al. (2012) have quantified the selection opportunity, reporting a threefold range in isoprene emissions among 30 poplar varieties. The variation allows for the selection of poplar varieties with reduced rates of isoprene emissions.

5.3.3 THE WESTERN MONTANA CORRIDOR PROJECT

The NARA team leadership identified the region between Columbia Falls and Missoula, Montana as the initial community development zone for a bioenergy and bio-products industry complex having many facets of the supply chain spectrum. This initial region was named the western Montana corridor. GreenWood Resources attended a NARA community meeting in Missoula in June 2012. During the meeting GreenWood participated in several conversations with entities that were potentially interested in a sustainable biomass supply from purpose-grown tree energy farms. One of the parties, Rivertop Renewables, is a Missoula chemical company that manufactures bio-products from sugar derivatives (e.g. glucaric, xylaric, arabinaric, and mannaric acids) with which the company's produces polymers for the manufacture of absorbents, adhesives, films, fibers, and various composites. GreenWood perceived sufficient interest in poplar biomass to initiate a strategic plantation business evaluation plan for the corridor.

The objective of the plan was to:

1. Complete a land study of the western Montana corridor to quantify the amount of suitable sites for poplar production.
2. Develop a silvicultural plan specific for the major plantation sites that would be needed to produce a sustainable supply of biomass.
3. Estimate the yield potential for major plantation site categories for the region and identify limiting factors to cost-effective biomass production.
4. Conduct an economic analysis for the major plantation site categories. This is the major deliverable for this preliminary project report.

Key to the strategic assessment is a poplar testing program that GreenWood has conducted since 2009 with Flathead Valley Community College in Kalispell. Growth and yield and clonal varietal performance data from the plot is indispensable to the strategic plan.

Two foundational points define the strategic planning process. First, GreenWood recognizes that the NARA feedstock strategy relies upon logging residuals that follow saw log harvests as well as biomass from thinning operations as the sole source of renewable biomass. Thus the poplar plantations are envisioned as a supplementary supply. GreenWood's expectation is that hybrid poplar biomass plantations may not be cost competitive with logging residuals. Yet in order for NARA bio-refineries to secure requisite financing, their feedstock supply portfolios should require purpose-grown energy plantations as a mandatory addition to forest residuals. A portfolio that includes a component of purpose-grown trees will reduce supply and pricing uncertainties and improve refinery operations. Secondly, the western Montana corridor does not meet all of the requirements of a poplar bioenergy production program. The amount and distribution of precipitation within this region is the main limiting factor. Thus, the silvicultural plan by necessity includes irrigation in many cases. The region's mean winter minimum temperature is also a critical limiting factor. Here clonal selection based on the Kalispell plot plays a critical role in the identification of adapted plant material.

5.3.4 THE WESTERN MONTANA CORRIDOR LAND STUDY

5.3.4.1 Objective

GreenWood's land study was designed to delineate areas potentially suitable for sustainable poplar plantations in the western Montana corridor between Columbia Falls in the north and Missoula in the south. Public spatial datasets were relied upon to determine land and current use categories that fit descriptions for prospective poplar plantation developmental sites. The classifications developed from each of the spatial dataset were: (1) Gap Analysis of land use in agriculture, pasture, or haying, (2) Annual precipitation rates ranging from 15 to 40 inches within five inch increments, (3) Soil depth greater than 45 inches, and (4) Topography described as level or gently rolling with maximum slope of eight percent. The principal dataset employed was the U. S. Geological Survey's Gap system based on 2001Landsat imagery. The dataset contains 590 ecosystem classifications. Three other datasets were also used corresponding to average annual precipitation, soil depth, and topographic flatness.

5.3.4.2 Methodology

Columbia Falls and Missoula were treated in the land study as probable locations for refineries that would receive poplar plantation-grown biomass along with a larger supply of logging residuals (Figure 5.3.1). Concentric rings of 25, 50, and 75 mile radii centered on each of the two refinery locations were used to define likely plantation development areas in parcels of minimum size of 20 acres. This minimum provides sufficient area for headlands for machinery operation without too great a loss of actual plantation area.

5.3.4.3 Results

The evaluation of the U. S. Geological Survey's Gap dataset showed that there is a total of 681,079 acres meeting the identification criteria currently being managed for agriculture or for pasture and hay. When this subset was intersected with the other datasets classifying the amount of annual precipitation, topography, and soil depth, a total of 40,622 acres were noted that could be found within the concentric distance rings and receiving between 25 and 40 inches of annual precipitation (Table 5.3.1). Inspection of seasonal rain distribution showed that the precipitation mainly falls outside the growing season. Thus irrigation is essential throughout much of the corridor; this will have a decidedly negative impact on the economics of production. The follow-up inspection also showed that nearly all agricultural areas have developed pivot irrigation systems. The pastoral lands are generally situated at higher elevations with rolling terrain and are not set up for irrigation.

Assuming that 20 to 25% of the 40,622 acres receiving the higher rainfall amounts can be converted to biomass production, a total of 8,124 to 10,155 acres are available within the corridor for developing purpose-grown biomass to supplement the supply of logging residuals from local softwood forests. A base case scenario was developed around a 10,000 acre development on sites of reasonable agricultural quality managed with intensive cultivation without irrigation. This became the basis of comparison of incremental addition of irrigation and other management inputs.

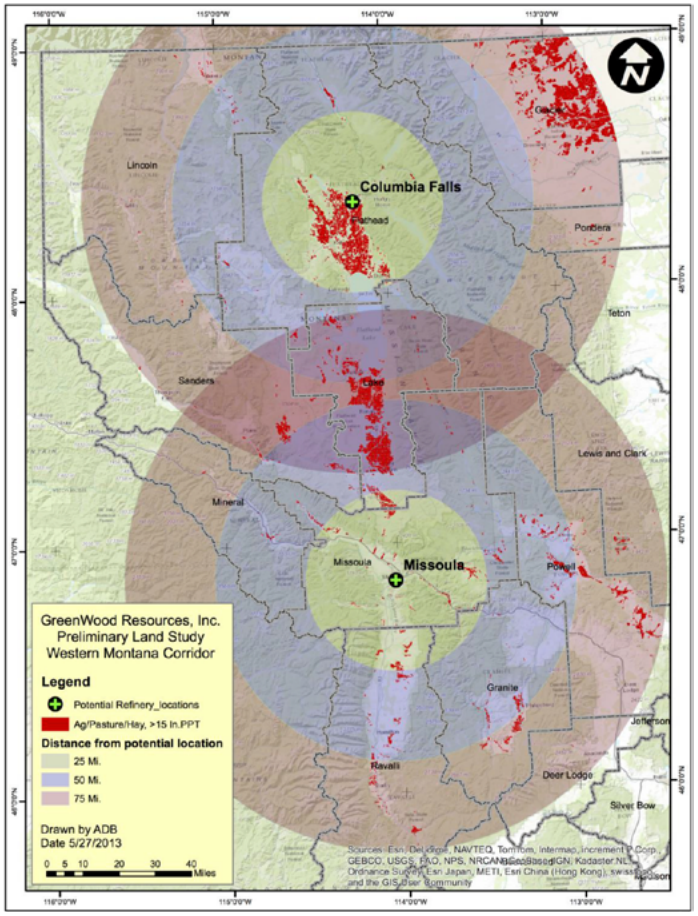

Figure 5.3.1. Preliminary land study of the Western Montana Corridor

Table 5.3.1. Results of WMC land study

Sum of Acres			Precipitation						
Location	Ring Miles	Grid Code	15	20	25	30	35	40	Grand Total
Columbia Falls	25	Agriculture		38275	4546	314			43135
		Pasture/Hay		33920	8738	1318	266		44242
	25 Total			**72195**	**13284**	**1632**	**266**		**87377**
	50	Agriculture	919	5642	247				6807
		Pasture/Hay	6241	10195	2440	728	25	34	19663
	50 Total		**7160**	**15837**	**2686**	**728**	**25**	**34**	**26470**
	75	Agriculture	33397	27295	4425				65118
		Pasture/Hay	46420	48500	4977	460	56		100413
	75 Total		**79818**	**75795**	**9402**	**460**	**56**		**165531**
Columbia Falls Total			86978	163827	25373	2819	348	34	279378
Missoula	25	Agriculture	4647	7620					12267
		Pasture/Hay	18275	15608	457				34340
	25 Total		**22922**	**23228**	**457**				**46607**
	50	Agriculture	38149	25861	937				64947
		Pasture/Hay	70765	55053	1220	156			127194
	50 Total		**108915**	**80914**	**2157**	**156**			**192141**
	75	Agriculture	28022	18674	455				47151
		Pasture/Hay	59553	47425	8319	481	25		115803
	75 Total		**87575**	**66099**	**8774**	**481**	**25**		**162954**
Missoula Total			219412	170240	11388	636	25		401701
Grand Total			**306389**	**334067**	**36760**	**3455**	**373**	**34**	**681079**

5.3.5 FEEDSTOCK PRODUCTION SYSTEM

A successful poplar program in the western Montana corridor will rely upon a tailored silvicultural program and the selection of adapted plant varieties. Appendix II, details the site preparation, crop care, and harvest activities for a 22-year coppice biomass production rotation. The structure of the 22-year rotation includes an initial planted stage that is harvested following two full growing seasons to initiate the first of five successive four-year coppice cycles. The set of silvicultural activities assumes the sites to be planted are either currently, or have recently been managed for pasture, haying, or crop production. The table also shows per-acre activity costs including those for operating and maintaining drip irrigation systems where applicable. Land and capital costs as well as management fees are not included in Appendix II, although they are included in the following section's economic analyses.

5.3.5.1 Soils

The major soil types that would be targeted for project development in the northern portion of the corridor in Flathead County are Swim silt loam, Kiwanis fine sandy loam, and Walters very fine sandy loam. Likewise in the southern portion of the corridor in the vicinity of Lake County, there are three soil types that would be most suitable for poplar plantation development. These are more consistent in textural classification and include Polson, Gird, and Lonepine silt loams. All of these soil types have good structure for poplar management with a depth-to-water table of 48 to 80 inches (Appendix I). Supplemental irrigation is a likely requirement of poplar production in nearly all situations in view of the limited growing season precipitation.

5.3.5.2 Site Preparation

Crop survival and optimum growth over the rotation are linked to the quality of site preparation. Site prep begins the year prior to planting with measures to control existing vegetation taking place in June through the application of a contact herbicide (glyphosate and/or 2,4-D). The site is not disturbed for at least seven days following the chemical application. Chemical weed control is followed by one or two passes with a heavy breaking-disk in July or August, then one pass with a finish disk and a cultipacker to smooth the surface. At this point, the site should be free of weeds with a maximum clod size of two inches. Subsoiling or chisel plowing is scheduled in the late summer or early fall to loosen any dry or compacted profiles while also marking the planting rows. Rows should be ripped to a depth of 16 inches to accommodate the planting of 18 inch cuttings. Dry fertilizer (nitrogen, phosphorus, potassium) is added at this time in quantities based on soil tests. Irrigation tube layout is scheduled after ripping in the late summer or fall, or in the spring of the planting year. Rows are oriented parallel to the long axis of the field to maximize harvesting efficiency. Row lengths must provide adequate space for turning the harvesters and the accompanying transport equipment used to convey material to the field edge for loading.

A second herbicide application is made in the fall in the form of a contact chemical to control re-sprouted weeds with the optional addition of a pre-emergent herbicide to control the germination of weed seeds over the remainder of the fall and through the following spring. A third application of a contact and pre-emergent chemical mix is made in the spring just prior to planting to ensure a weed-free condition into the early and middle part of the first growing season.

5.3.5.3 Poplar Varietal Selection

The use of superior clonal varieties and quality planting stock is essential for successful plantation performance. Five selected varieties from three taxa have proven well in GreenWood's collaborative clonal trials in Kalispell and Caldwell, Idaho, and are the ones likely best suited for the Western Montana corridor project. These five varieties originate in the following taxa: (1) Two from the P. ×canadensis (P. deltoides × P. nigra) taxon, (2) one from the P. deltoides × P. maximowiczii taxon, and (3) two from the P. ×generosa (P. trichocarpa × P. deltoides) taxon (Appendix III). The mean age-four height of the five topmost varieties in the Kalispell trial is 30 feet. The projected mean annual biomass increment (MAI) of these selections varies from 3.7 to 4.6 bone dry tons per acre (Appendix III). It is noteworthy that nearly all five selections are bred using P. deltoides selections from provenances from the North Central region, a reflection of greater adaptation to western Montana winters.

5.3.5.4 Crop Establishment

Poplar bio-energy plantations are established at density of 1,450 stems per acre. Rows are spaced 10 feet apart; three feet separate each tree within the row. Silvicultural activities in Appendix II are based on plantations established from unrooted cuttings 18 inches in length. This cutting length provides for good establishment under the typically dry conditions of western Montana and irrespective of whether irrigation is applied. Cuttings are collected in December through February from stoolbed nurseries and held in frozen storage until field planting.

Proper planting technique is among the most critical steps in successful plantation establishment. The cuttings should be planted in the soil to a depth of no less than 80% of their length to produce a favorable root-to-shoot ratio during the establishment phase when adventitious rooting is taking place. Cuttings must be planted with a vertical orientation. At least one axillary bud should be at, or above soil level. If irrigation is applied, the system should be functional and water running at the time of planting so that the cuttings are inserted into moist soil. Soil must be firmly packed around each cutting, eliminating air pockets, and allowing the soil to be fully in contact with the cutting to encourage vigorous rooting. Cuttings are normally planted by hand using labor crews to stick the cuttings into the ripper lines and firm up the soil. Varieties are deployed as monoclonal blocks.

5.3.5.5 Crop Care, Initial 2 Year Cycle

Clean cultivation promotes rapid site capture by the stand precluding weed competition for soil moisture, light, and nutrients. Two between-row mechanical cultivations are scheduled in early and late summer during each of the first two growing years. Tractors and implements are sized to fit between the 10-foot tree rows allowing for a minimum one foot clearance on either side. Within-row weed control is manually effected through hoeing or spot spraying using a shielded herbicide spray wand. Each entry into the field for within-row weed control is anticipated to cover 50% of the acres during the initial two-year stage (Appendix II). Irrigation application during the first year approximates 12 acre inches. This increases to 14 acre inches in year two. Insect pests are intermittent or localized in their occurrence; the schedule of pest control treatments in Appendix II assumes that 25% of the acres require control in any given year. Disease prevention is assumed to be provided through the deployment of resistant varieties.

5.3.5.6 Crop Care, 5 Repeated 4 Year Cycles

In preparation for the coppice phase of the 22-year rotation, weed control resumes during the first season after the initial harvest at a less intensive level with pre-emergent chemicals applied before sprouting of the stand. The pre-emergent application is followed by one or two entries into the field for within-row spot spraying or manual mechanical weed control. Mechanical tractor cultivation is also scheduled for one or two entries into the field for between-row control. The intensity of weed control declines in the second year of the coppice cycle as the crop recaptures the site; weed control is discontinued in years three or four of each coppice cycle.

Pest control continues at the same level as in previous years; the schedule of activities in Appendix II anticipates an annual treatment rate of 25% of the plantation acres. Annual application of liquid fertilizer may be recommended based on the results of soil nutrient analysis. Otherwise dry fertilizer is banded along the tree rows the spring following harvest. Irrigation application increases steadily as the crop matures through the fourth growing season from coppice, moving from 12 acre inches to 18 acre inches, in steady uniform annual increments. These irrigation rates are suggested applications, as crop demand will vary by site, available rainfall, soil type, and climate conditions. Costs shown in Appendix II are based on delivered water cost at $ 5.00 per acre inch.

5.3.5.7 Harvesting and Yield Projections

Harvest is initiated at the end of the second growing season of the initial planted cycle. This first harvest is not anticipated to fully reflect the growth and yield potential of the plantation, but serves to initiate the ensuing coppice cycles where full yield potential is realized (Appendix IV). Current harvesting technology utilizes a specialized harvesting head to sever the stems from the stumps which are then fed into a conventional agricultural forage chopper that chips the trees and blows the mass into a trailing truck or dump wagon. (Irrigation components are removed from the field prior to entry by harvest equipment.) Biomass is unloaded into road-ready trucks for transportation to the refinery. Temporary chip piles may be created either at the refinery or at the plantation to build an inventory as a hedge against supply constraints during the harvest period. Although a “just-in-time” delivery system is ideal for biomass harvesting, temporary piles up to 1,000 green tons can be produced and held for up to three months with moisture loss only in the outer portion of the pile and minimal deterioration within the pile. At the conclusion of the fifth and final coppice harvest, the field will be restored to a pre-poplar stand condition and prepared for another rotation of hybrid poplar biomass production.

The estimation of biomass mean annual increments (MAI) for the project was projected from data from the top clones from the Kalispell clone trial that were extrapolated to a per-acre basis (Appendix III). GreenWood biomass equations were used in the expanding individual stem weights to a stand distribution of 1,450 trees per acre. MAIs range from a low of 3.7 bone dry tons (BDT’s) (P. ×canadensis) per acre per year up to 4.6 BDT’s per acre per year (P. ×generosa). The MAIs used in the economic model to bracket these ranges were 2.8 BDTs for lower quality sites to 4.9 BDTs for higher quality sites to account for the effect of varying soil quality and irrigation. Harvest costs in Appendix II are based on an optimum projection of 19.6 BDTs per acre. Moisture content of 57% water is incorporated into the production cost calculations, as harvest costs are based on a green ton basis.

5.3.6 ECONOMIC ANALYSIS

5.3.6.1 Modeling Objectives

The primary objective of the economic analysis was to evaluate the commercial viability and performance of developing and managing a 10,000 acre hybrid poplar energy plantation located within 75 miles of potential refinery locations in Missoula and Columbia Falls. The coppice management scheme was modeled as the most suitable silvicultural system to achieve the investment objectives. Break-even pricing was derived and the sensitivity of key profitability drivers was evaluated to assess the impact on the IRR of the project. The analysis looked at biomass production as a function of site quality categorized as agricultural (level terrain, higher productivity) with and without irrigation and pasture (rolling, lower productivity) without irrigation. The project-level analysis focused on achieving sustained production levels and biomass delivery at or below threshold prices, factoring the amount and cost of suitable land and transportation distances to refineries. The key elements addressed in studying and modeling the plantation development project were:

1. Land quality.
2. Mode of land acquisition; impact of land pricing and distance from facility.
3. Irrigation requirement and profitability.
4. Total area of land needed for required production.
5. Minimum scale of plantation required for economies of scale.
6. Timing of land acquisition and decision to lease as opposed to a purchase option.
7. Modifications in coppice rotations during the transition phase of land development to achieve the level of sustainable fiber production.

A forest-level modeling system (Woodstock) was used to simulate dedicated bioenergy plantation development and management to produce a sustainable fiber supply over a range of land parcels varying in current land-usage, biomass productivity, lease rate, and distance from potential processing facilities. Woodstock optimization capability determines the most productive, cost effective and profitable way to develop and manage plantation resources to deliver required biomass supplies. Woodstock was used to provide long term wood supply and cash flow forecasts which were exported to financial models to evaluate financial performance (breakeven analysis, IRR, NPV) and perform sensitivity analyses. The cash flow profile, level of required capital investment, and timberland asset valuations for investment entry and exit decisions are optional outputs for such ventures.

5.3.6.2 Model Inputs

Plantation Development Strategy - The analysis was structured on the development of a fixed 10,000 acre plantation that would produce a sustainable volume varying between 28,000 and 46,000 BDT per year dependent on land quality. Two zones of 5,000 acres of plantations concentrated around Missoula and Columbia Falls were assumed. An initial two-year planted cycle followed by a succession of four-year coppice cycles was also assumed. Land development rate was set at 2,500 acres per year for the first four years. If scaling up at this rate is not possible due to land availability, then deviation in the cutting cycle lengths and associated yields will be necessary to provide sustained biomass production. This issue is not addressed in the modeling exercise under the assumption that any deficits in dedicated plantation wood supply could be offset by increasing the amount of biomass originating as logging and thinning residuals.

Land - Based on the GIS land study, it was determined that the land supply is not constrained when the project is scaled to 10,000 acres. The land base considered for this study includes: (1) Productive agricultural land of generally level terrain with irrigation infrastructure and access to deep wells and (2) Less productive pastoral lands of rolling terrain unsuitable for irrigation. Given the probability

Table 5.3.2. Historical land lease rates in the WMC. Sources: http://www.nass.usda.gov/Statistics_by_State/Montana/Publications/Annual_Statistical_Bulletin/2011/economic.pdf
http://www.nass.usda.gov/Statistics_by_State/Montana/Publications/Annual_Statistical_Bulletin/2012/EcoCashRents.pdf

Processing Facility Location	Missoula					Missoula & Columbia Falls					Columbia Falls					NW Montana Average				
County	Missoula					Lake					Flathead									
Year	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
Irrigated agricultural land			25.50		31.50	56.50	78.00	73.00	64.00	62.50		64.00	64.00			50.50	63.00	63.00	53.00	80.00
Non irrigated agricultural land										29.50		30.50					24.50			23.00
Pasture	41.50	16.50	18.00			13.50	10.00	19.00	10.50	10.00		8.40	3.30		9 .00	12.00	9.30	9.80	9.20	8.10

that only a portion of this land base within the preferred 25 mile radius would be available and the block sizes may not be adequate, 5,000 acre land banks within 75 miles (weighted average of 50 miles) from Missoula and Columbia Falls were assumed to be potentially available.

The price for land in the surrounding counties was evaluated and an average annual lease rate of $65 per acre was assumed applicable for the base case economic analysis of agricultural land. The lease rate for pastoral ground was $10.00 per acre per year (Table 5.3.2).

Silviculture and Yields - The plantation models are based on the feedstock production system described in Appendix II. The salient elements are establishment by cuttings at a stocking rate of 1,450 stems per acre. The plant material base would be made up of tested varieties of three adapted hybrid taxa. Stands are managed on a 22-year rotation distributed as an initial two-year coppice set-up, plus five cutting cycles of four years each. Harvesting on repeated four-year coppice cycles is gauged to be optimum in terms of maximizing recovered yield. Irrigation is assumed on the agricultural sites but not the pastoral land. The per-acre MAI for the agricultural sites is assumed at 4.9 BDTs per acre and 2.8 BDTs per acre for the lower quality, pastoral sites.

Operating Costs - The cost structure associated with site preparation, crop care, and harvest operations described under feedstock production are based on preliminary estimates from comparable coppice bio-energy plantations and adjusted for local farming contractor rates (Appendix II). However, the cost structure reflects the higher end of the spectrum for intensive levels of site preparation and ongoing crop care. In practice, some variable operational costs will likely be lower (e.g. weed and pest control costs). It is probable too, that fertilizer requirements can be reduced depending on soil type. All costs are modeled in real terms.

Irrigation Options - The productivity of bioenergy coppice plantations can be enhanced through irrigation on dryland sites targeted for this economic analysis. The agricultural lands are high quality soils with good nutrition levels and water retention capacity. But where annual precipitation is less than 30 inches that is not evenly distributed, irrigation is a necessary option to enhance survival, growth, and biomass yields. Modeled irrigation system costs are specific to a drip system with irrigation hoses placed along each planting line. This system requires the placement of pumps on wells. Modeling includes the cost of hose removal and roll out at the beginning and end of each harvesting operation, respectively. The cost of annual irrigation is comprised of water plus electricity for pumps.

Fertilizer Options - The western Montana production system is modeled assuming fertilizers would be applied. GreenWood's opinion is that as the project develops fertilization may not be required on agricultural sites at the frequency or concentrations prescribed. When applied, however, nitrogen would be as a liquid amendment delivered through the drip irrigation system. On non-irrigated, pastoral sites the fertilizer would be applied during initial site preparation by incorporation into the rip lines and subsequent applications would be made after each harvest cycle by banding alongside the stool rows.

Capital Costs - Modeled capital costs are limited to irrigation development. Most leased agricultural properties include wells and a network of roads of adequate density and grade for coppice plantation management. The capital cost of a "greenfield" development of a drip irrigation system is approximately $1,000 per acre for land blocks ranging from 200 to 500 acres. This scale is required for an efficient design of pump systems, filters, and controls. Capital costs increase significantly for smaller parcels of land. All mechanized operational capital cost are embedded in contract rates for operation; no machinery or equipment cost are directly modeled. Similarly, no buildings or vehicle fleets are included, as these are contained in the structure of the management fee.

Harvesting and Biomass Transport Costs - Harvesting costs are estimated on a per acre basis. The initial age-two harvest operations of small dimension coppice shoots is $249.53 per acre, while subsequent cutting cycle harvests of large coppice is $569.77 per acre. Costs include in-field harvest and chipping, and transport to field edge. The cost of biomass transportation to refineries is based on chip vans with a 30 green ton capacity and a 57% biomass moisture content. These are estimated at $1.94, $3.88, and $5.81 per BDT for haul distances of 25, 50, and 75 miles, respectively.

Management Fees and Other Indirect Costs - Many of the indirect costs associated with farm operations and management are fixed and therefore scalable, while others are proportional to acreage. In the economic model, these costs were scaled to a 10,000 acre operation. The cost allocations and applied rates could be significantly different depending on the services required, scale of the venture, and the aggregation level of plantation blocks. Annual management fees include the following:

1. Investment Management Fees ($10 per acre): Investor reporting and liaison, research and development, subscriptions/memberships, software licensing, other business G&A.

2. Property Management ($30 per acre): Contract management, legal services, strategic/operation planning, resource analysis, valuations, accounting, budgets, financial forecasting.

3. Operation Management ($30 per acre): Personnel management, industry/local government and landowner/community interaction, plant material sourcing, crop monitoring, operational planning and logistics, contract negotiation, supervision and quality control, plantation protection, health and field data collection, vehicles and buildings.

4. Plantation Protection, Maintenance, and other Indirect Project Expenditure
   - a) fire suppression: $ 0.50 /acre/year
   - b) firebreak maintenance: $ 0.50 /acre/year
   - c) road maintenance, internal and external access: $ 1.00 /acre/year
   - d) mapping and GIS: $ 0.50 /acre/year
   - e) stand inventory: $ 1.00 /acre/year
   - f) foliar and soil analyses: $ 0.50 /acre/year
   - g) land lease: $ 65.00 /acre/year (agricultural sites) and $10.00 /acre/year (pastoral)
   - h) financial audit: $ 2.00 /acre/year
   - i) third party appraisal: $ 2.00 /acre/year
   - j) insurance: $ 2.00 /acre/year

Key Drivers and Sensitivity Factors - The break-even price required for a bioenergy plantation was modeled along with a sensitivity analysis for a wide range of potential prices including market pricing at the bio-refinery gate (unloaded). All prices and costs are expressed on a per acre or bone dry ton basis. The main variables evaluated included:

1. Market price of biomass
2. Land productivity
3. Transportation distance between plantation and biorefinery
4. Land lease rates
5. Application of fertilizer and irrigation

5.3.6.3 Major Findings

Relative profitability of different land classes – Agricultural land is more suitable than pastoral land despite land cost differences as the growth rates and yields are higher. Coppice systems developed and managed on agricultural land with irrigation are more profitable than those of pastoral operations despite higher lease costs. Mechanized harvesting systems are likely to be more productive and operate at a lower unit cost on agricultural sites of level terrain than rolling pastoral lands. Also the road infrastructure is more extensive providing easier access and shorter haul distances to field edge.

Relative profitability of varying haul distances – The profitability of coppice systems obviously diminishes with increased distance from delivery points, but the sensitivity of irrigated lands on agricultural sites is low due to the comparatively higher productivity rates. The profitability of the non-irrigated pasture lands is more sensitive to haul distance despite lower costs structures due to their lower productivity status.

Relative profitability of irrigated and non-irrigated sites – The rainfall received on the majority of the land in the study zone ranges from 15 - 20 inches (Table 1). This is largely seasonal and falls outside the growing season so dependency on irrigation is necessary on both agricultural and pastoral. However, the use of irrigation is precluded on pastoral lands due to the absence of irrigation infrastructure. Furthermore the terrain of the pastoral sites is a limitation to effective irrigation. Thus, pastoral lands cannot be effectively utilized without exposure to higher levels of crop failure or lower growth rates. The productivity and financial returns of irrigated sites exceed those of non-irrigated sites. Irrigation costs are associated with higher annual lease costs.

Plantation development strategy – Plantation blocks of at least 200 – 500 acres are needed for cost-effective drip irrigation management. These can be aggregated in clusters of 20 acre blocks that exceed the threshold for cultivation and harvesting efficiencies. Under the base scenario, a 15 million dollar capital investment is required to build up the 10,000 acres to generate the annual production of 46,000 BDTs. A five to 10% acreage buffer is factored in to accommodate potential plantation under-performance due to slower-than-anticipated growth. Capital inflow is expected for the initial six years until production revenue is generated from the project.

Finding – Dedicated bioenergy plantation development in the western Montana corridor is considered financially feasible and can generate real returns in excess of 10% at market prices of $150/BDT. The break-even market prices (Project IRR = 0%) are sensitive to distance, land costs and land productivity, and for the base case scenario - sites of reasonable agricultural quality managed with intensive cultivation without irrigation is $115/BDT (Table 5.3.3). Comparable information is not presented from the analyses of the pastoral sites modeled at a base MAI of 2.8 BDT production and a $10.00 an acre annual lease. The investigation of the pastoral land development of rolling terrain led to the conclusion that coppice biomass farming is not practical due a variety of risk and operating factors (e.g. mechanization, infrastructure, logistics).

The success of the bioenergy plantations is very sensitive to, and contingent on, the availability of 10,000 acres of mostly agricultural land that needs to be concentrated within a weighted average hauling distance of 50 miles of a bio-refinery to maintain required level of plantation profitability. The development should ideally be conducted by phasing in the leasing of land in equal portions over the target harvesting cycle lengths. This will lead to an even distribution of plantation age classes that will expeditiously achieve the maximum sustainable production while creating an even flow of work for farm operations.

Table 5.3.3. Break-even price analysis and internal rate of return for management options for ag sites with irrigation capacity

Model Var.	Scenario	Market Dist. (mi)	Yield (High/Low%)	Irrigation Status	Fertilizer	Lease ($/acre)	Refinery Price ($/BDT)	Pre-Tax IRR	Note
	Base case	50	100:0	No irrigation	periodic	65	150	10.4%	1
Market Price Changes	market -$10/BDT	50	100:0	No irrigation	periodic	65	140	8.2%	
	market -$20/BDT	50	100:0	No irrigation	periodic	65	130	5.7%	
	market -$30/BDT	50	100:0	No irrigation	periodic	65	120	2.5%	
	market -$35/BDT	50	100:0	No irrigation	periodic	65	115	0.2%	
Land Productivity	High Land Productivity	50	75:25	No irrigation	periodic	65	150	8.2%	
	Average Land Productivity	50	50:50	No irrigation	periodic	65	150	5.6%	
	Low Land Productivity	50	25:75	No irrigation	periodic	65	150	2.2%	
	Low Land Productivity	50	0:100	No irrigation	periodic	65	150	0.0%	
Transport Distance	Transport - 25 miles	25	100:0	No irrigation	periodic	65	150	11.2%	2
	Transport + 25 miles	75	100:0	No irrigation	periodic	65	150	9.7%	
Land Lease Rates	Lease - $20/acre	50	100:0	No irrigation	periodic	45	150	11.9%	
	Lease - $10/acre	50	100:0	No irrigation	periodic	55	150	11.2%	
	Lease + $10/acre	50	100:0	No irrigation	periodic	75	150	9.7%	
	Lease + $20/acre	50	100:0	No irrigation	periodic	85	150	9.0%	
Irrigation & Fertilizer	No irrigation, no fertilizer	50	100:0	No irrigation	none	65	150	11.1%	3
	Irrigation - annual fertilizer	50	100:0	Irrigated (drip)	drip	65	150	3.1%	4
	Irrigation - fertilizer periodic	50	100:0	Irrigated (drip)	periodic	65	150	3.9%	

Note 1: Break-even delivered price = $114.68/BDT
Note 2: Land lease rate positively correlated to productivity, but keep lease cost constant to model impacts of productivity. Fertilizer cost deducted but no change in yield projections.
Note 3: Fertilizer impacts on productivity not known.
Note 4: Break-even delivered price = $137.91/BDT

Table 5.3.4. Cash flow of base case scenario of bioenergy plantation development in Western Montana Corridor

Cash Flow and Return on Investment Analysis (Before taxes)																							
Investment Model for:	NARA Bioenergy Plantation Development & Management																						
Model Scenario:	Scenario 1 - Base Case																						
Date:	6-Jun-2013																						
CURRENCY: USD			2013 Year 0 1/1/2013	2014 Year 1 1/1/2014	2015 Year 2 1/1/2015	2016 Year 3 1/1/2016	2017 Year 4 1/1/2017	2018 Year 5 1/1/2018	2019 Year 6 1/1/2019	2020 Year 7 1/1/2020	2021 Year 8 1/1/2021	2022 Year 9 1/1/2022	2023 Year 10 1/1/2023	2024 Year 11 1/1/2024	2025 Year 12 1/1/2025	2026 Year 13 1/1/2026	2027 Year 14 1/1/2027	2028 Year 15 1/1/2028	2029 Year 16 1/1/2029	2030 Year 17 1/1/2030	2031 Year 18 1/1/2031	2032 Year 19 1/1/2032	2033 Year 20 1/1/2033
REVENUE																							
Biomass sales																							
Delivered bioenergy facility			0	0	0	2,250,000	2,250,000	2,250,000	2,250,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000	6,900,000
Field edge			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propagation materials																							
Cuttings			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rods			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL INCOME		**0**	**0**	**0**	**2,250,000**	**2,250,000**	**2,250,000**	**2,250,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**	**6,900,000**
COGS																							
Timber Depletion			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temporary harvest roading			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Harvesting & transport to field edge			0	0	0	623,825	623,825	623,825	623,825	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425	1,424,425
Loading			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Harvest management			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road usage & other taxes			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transport cost to processing facility			0	0	0	134,850	134,850	134,850	134,850	413,540	413,540	413,540	413,540	413,540	413,540	413,540	413,540	413,540	413,540	413,540	413,540	413,540	413,540
Contingency			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collection & storage of propagation materials			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transport of propagation materials			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total COGS		0	0	0	758,675	758,675	758,675	758,675	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965	1,837,965
	GROSS PROFIT		**0**	**0**	**0**	**1,491,325**	**1,491,325**	**1,491,325**	**1,491,325**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**	**5,062,035**
EXPENSES																							
Tree Farm Expenses																							
Silvicultural treatments																							
Weed Control			0	100,000	200,000	300,000	383,000	333,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000	233,000
Cultivation			0	150,000	300,000	450,000	600,000	450,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Fertilizer			0	0	0	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500
Other			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation																							
Irrigation tube layout / start-up / removal			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation water / electricity			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest Protection & Maintenance																							
Pest & Disease Control			0	0	34,375	68,750	103,125	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500	137,500
Forest Health (Pest & Disease) Monitoring			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest Security			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire control			1,250	2,500	3,750	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Firebreak & boundary maintenance			1,250	2,500	3,750	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Road Maintenance& Storm Damage Cleanup			2,500	5,000	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Other			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Tree Farm Expenses		5,000	260,000	549,375	951,250	1,218,625	1,053,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000	803,000
Company Expenses																							
Property Leases			162,500	325,000	487,500	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000
Fire Insurance			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mapping & GIS			1,250	2,500	3,750	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Forest Inventory			2,500	5,000	7,500	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Soil & Foliar Analyses			1,250	2,500	3,750	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Government permits & fees			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Community development			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Environmental certification			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Legal Fees			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Financial audit / accounting fees			5,000	10,000	15,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Appraisal			5,000	10,000	15,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Other company expenses / G&A			5,000	10,000	15,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
	Total Company Expenses		182,500	365,000	547,500	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000	730,000
Management Fees																							
Operation Management Fee			75,000	150,000	225,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Property Management Fee			75,000	150,000	225,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Investment Management Fee			25,000	50,000	75,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
	Total Management Expenses		175,000	350,000	525,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000
	TOTAL EXPENSES		**362,500**	**975,000**	**1,621,875**	**2,381,250**	**2,648,625**	**2,483,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**	**2,233,000**
	OPERATING CASHFLOW		**(362,500)**	**(975,000)**	**(1,621,875)**	**(889,925)**	**(1,157,300)**	**(991,675)**	**(741,675)**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**	**2,829,035**
CAPITAL COSTS																							
Timber and Timberland																							
Land purchase			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing biomass crops			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Establishment & Silviculture																							
Site Preparation - herbicide			237,500	375,000	512,500	650,000	550,000	412,500	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000
Site Preparation - disk			162,500	162,500	162,500	162,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site Preparation - row mark & rip			62,500	62,500	62,500	62,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planting			0	1,160,000	1,160,000	1,160,000	1,160,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Land Improvements / Infrastructure																							
Access Road Construction			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Firebreak Construction			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation Capital			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vehicles & equipmnet			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buildings			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Fixed Assets			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL CAPITAL		**462,500**	**1,760,000**	**1,897,500**	**2,035,000**	**1,710,000**	**412,500**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**
	Add back non-cash expenses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL NET CASH FLOW		**(825,000)**	**(2,735,000)**	**(3,519,375)**	**(2,924,925)**	**(2,867,300)**	**(1,404,175)**	**(1,016,675)**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**	**2,554,035**
	CUMULATIVE NET CASH FLOW		(825,000)	(3,560,000)	(7,079,375)	(10,004,300)	(12,871,600)	(14,275,775)	(15,292,450)	(12,738,415)	(10,184,380)	(7,630,345)	(5,076,310)	(2,522,275)	31,760	2,585,795	5,139,830	7,693,865	10,247,900	12,801,935	15,355,970	17,910,005	20,464,040
	Period - End Terminal Value at IRR		982,268	3,818,779	7,732,803	11,456,867	15,508,166	18,515,017	21,445,109	21,107,299	20,734,578	20,323,338	19,869,599	19,368,969	18,816,602	18,207,151	17,534,717	16,792,790	15,974,190	15,070,993	14,074,455	12,974,932	11,761,779
Internal Rate of Return		10.33%																					
ESTIMATED TIMBER VALUE (31 DEC)			1,435,725	4,314,298	8,265,103	12,016,538	16,065,492	19,098,216	22,024,712	21,673,149	21,286,428	20,861,036	20,393,105	19,878,380	19,312,183	18,689,367	18,004,268	17,250,660	16,421,691	15,509,825	14,506,773	13,403,415	12,189,722
Discount Rate		10.00%																					

5.3.7 RISK ASSESSMENT

Ventures in plantation development are naturally accompanied by a wide range of risk. Therefore, it is necessary to: (1) Isolate those that are material from those that are immaterial and (2) Determine appropriate courses of action for the material ones that will potentially add cost, reduce revenue, or increase earnings volatility.

Risks may be classified and addressed through a range of mechanisms:

1. Manageable risks – apply preventative or remedial silviculture measures.
2. Insurable risks – arrange for cost effective coverage.
3. Unforeseen business or market risks that decrease the expected revenue stream – reduce productive area for catastrophic losses; add contingencies to expenditures, reduce expected market prices; reduce expected net earnings and/or increase discount rate to a higher risk adjusted return level.
4. Acceptable and quantified potential risks – reduce expected net earnings and/or increase discount rate to a higher risk-adjusted return level.

The key risks for bioenergy plantation investment are outlined in table 5 along with the relative probability of occurrence and potential impact on the asset's profitability and growth in value. Operational and market risks vary with the project investment period and some will be reduced through management actions (e.g. adapting silviculture with experience and field trials to minimize crop losses; contracts to control operational costs, land lease contracts with terms to contain costs, wood supply contracts that maintain market security), while others will persist (e.g. markets), while others will increase with time (e.g. fire occurrence in advance coppice cycles).

The key risks that determine the financial performance of the venture are:

Availability and Price of Suitable Land – The bioenergy plantations are heavily dependent on the following:

1. Land base - Concentration of acreage within a reasonable radius of the refineries to minimize cartage costs.
2. Site quality - Productive soils to achieve target yields especially in areas with limited rainfall and where it is concentrated outside the growing season. Also important is land that has suitable terrain for mechanized operations.
3. Parcel size - Large, contiguous bocks of 200-500 acres are necessary to achieve economies of scale. Blocks of 20 acres are the minimum unit size for effective coppice plantation development; contiguous blocks or aggregates of blocks are recommended so as to attain operational efficiency and to reduce infrastructural and management overhead rates.
4. Support services - Access to agricultural and forestry expertise and capability for land preparation, crop care, and harvesting operations and transport. Access to service industries for maintaining vehicles and machinery.
5. Lease program - Ability to lease the minimum level of land (10,000 acres in this scenario) for progressive property development to achieve sustainable fiber production that meets contractual wood supply volumes. The dominant land use in the proposed investment zone is cropping and grazing. Although there are adequate lands within close proximity of potential refinery locations in the corridor, the performance of current land uses will determine land availability and lease rates.

Market prices for biomass – Bioenergy plantations are intensive operations that have a high cost structure. According to the base case scenario – quality agricultural sites, MAI of 4.6 BDT per acre, no irrigation, the feasibility and 27 financial profitability is contingent on a minimum breakeven prices of at least $115/BDT. The volatility in prices for biomass delivered to bio-refineries will be heavily impacted by the following:

1. Bioenergy final product market prices.
2. Fiber supply balances and prices for substitutes (e.g. non-cellulosic sources of sugar).
3. Government intervention (e.g. incentives, taxes)
4. Decisions by refineries as to whether to maintain the consumption of plantation fiber for the critical investment term of the poplar plantation (i.e. the payback period).

Achieving Target Growth Rates and Yields on Non-Irrigated Land – The large majority of the potential investment area receives less than 25 inches of rainfall per year. Moreover this is unevenly distributed seasonally. While the target mean annual increments are achievable, doing so is contingent on:

1. Regular rainfall. Prolonged drought will significantly impact growth rates, affect the length of cutting cycles or yields, and will increase production costs. The venture will be exposed to failure to meet contracted biomass supply volumes.
2. Attaining high survival rates. The quality of planting materials and effective weed control are critical during the formative stages of the tree stand.

3. Low levels of pests and diseases. The extent and the severity of disease infections and insect infestations can materially impact of tree survival, vigor and yield, though their impact can be mitigated by factoring in crop monitoring and protection activities.

Table 5.3.5. Key risks for bioenergy plantation investment

Source	Types of Risk Present	Potential Risk of Occurrence	Potential Value Impact
Market Risk	Risk - prices an/or implied volatility will change.		
	Commodity risk - market prices biomass or competitive substitutes; maintained demand level to absorb full production level.	High	High
	Land availability risks - limited supply of available land, high initial or renewal lease rates	High	High
	Financing - Equity Cost / Interest Rate Risk (D:E dependent)	Moderate	Low
Operational Risks	Risks associated with people, systems, processes and environment		
	Inability to achieve target growth rates & yields due to prolonged drought or inadequate silvicultural treatments	Moderate	Moderate-High
	Damage to Physical Assets - natural catastrophic events (drought, late frosts, snow damage, wind damage & fire)	Moderate	Moderate-High
	Pests & Diseases - spread more difficult to contain than hoped, incaresed incidence and impact in growth & yield	Moderate	Low-Moderate
	Legal Risk - Employment Practices and Workplace Safety - employee health and safety standards	Low	Low
	Business Disruption & Systems Failures - utility disruptions, computer failures	Low	Low
	Execution, Delivery, & Process Management - data entry errors, accounting errors	Low	Low
Credit Risk	Risk that a borrower will default. Lost principal and interest, disruption to cash flows, and increased collection costs.		
	Buyer of biomass defaults or goes into receivership	Low	Low
Country risk	Government Intervention		
	Government land-use policy & regulatory changes - incentives & taxation	Low	Moderate
	Price regulation (energy)	Low	Moderate
Liquidity risk	Asset cannot be traded quickly enough in the market		
	Limited market depth - specialized venture (limited market) and long term investment	Moderate	Low-Moderate

5.3.8 CONCLUSIONS

Strategic value of energy plantations – Hybrid poplar energy plantations offer a mechanism for rapidly producing substantive quantities of woody biomass for bioenergy facilities in areas of limited wood supply in western Montana. The NARA biomass supply strategy for this region is largely dependent on residual materials from logging and thinning operations in coniferous forests. Reliance on this source may be accompanied by a degree of uncertainty due to cyclicality in solid wood markets. Environmental concerns may also impact supply availability. Poplar plantations managed as a dedicated supplementary supply offer resource security that may be essential for refinery capital investments. The ability to consistently supply biomass at controllable prices can be maintained through large-scale plantation blocks within economic cartage distances.

Preliminary economic analyses isolate key drivers and constraints for profitable plantation development –

1. The most suitable biomass production system uses locally adapted poplar clonal varieties grown at high density under coppice management. The silvicultural regimes evaluated were modeled using a 22-year rotation composed of an initial two year cycle from planting followed by five successive coppice cycles of four years each.
2. A 10,000 acre operation represents approximately one-quarter of the agricultural and pastoral land base in the western Montana corridor that receives 25 to 40 inches of annual precipitation. Agricultural land offers the more favorable option for bioenergy plantation development to achieve satisfactory yields relative to the cost of the land. Pastoral lands of lower productivity and rolling terrain provide less favorable economics due to lower soil quality and biomass productivity combined with higher costs of mechanized cultivation and harvesting operations.
3. On higher quality agricultural sites receiving 25 to 40 inches of annual precipitation and assuming good seasonal distribution, a MAI of 4.6 BDT per acre may be achievable without irrigation. With irrigation, the attainment of comparable growth rates can be ensured across a greater area of the corridor's agricultural region where precipitation is limited, but the financial yields are lower. Thus irrigation is not recommended for coppice plantation development on financial grounds, but it is nonetheless very likely essential for the sustainability of yield.

Economic viability contingent on key variables – The ability to secure sufficient quantity of agricultural land in large contiguous blocks within an economic fiber cartage distance of the potential bioenergy processing facilities is essential. The cost of land leases represents a significant impact to program profitability, so it is necessary to: (1) Achieve full site utilization and maximize growth rates through effective plantation establishment, intensive silviculture and crop protection; (2) Long term leases at or below trend line rates need to be secured to contain land costs; and (3) Efforts need to be made to secure agricultural land with the minimum of necessary land improvements.

The project viability is sensitive to the level of indirect costs. The scale of operation (contiguous areas with a minimum of 200 – 500 acres) is critical to keep fixed costs low especially if the irrigation option is selected. Much of the agricultural land in the Missoula-Columba Falls corridor has irrigation infrastructure but designing and setting up pumps and distribution tubes requires scale to contain costs per unit area. Similarly, management fees are significant due to the high level of crop monitoring, high frequency of operations, and potentially large number of individual properties dispersed within the necessary transportation radius of the biorefinery. These costs are extremely scalable at the individual farm and project level.

Next Steps: The need to refine input data to validate and enhance potential investment returns – The economic returns of bioenergy plantation management are subject to a large amount of uncertainty and due diligence that would be required to evaluate the possible venture. Key areas of investigation include:

1. Comprehensive assessment of biomass fiber supply, demand, and pricing to determine future demand and price outlook.
2. Evaluation of availability of suitable land (soil quality, soil pH, precipitation rates and distribution patterns, lease price, productivity, terrain, contiguous blocks of minimum 200-500 acres, good road access, located within an economic radius of refineries).
3. Research trials to confirm growth rates and recoverable yields of coppice, susceptibility to pests and diseases, cost effective fertilizer application rates and techniques.
4. Evaluation of silvicultural system (different planting densities and cutting cycle lengths) to maximize financial yields.
5. Continued evaluation of harvesting systems (equipment, scale of operations, coppice density and size).
6. Evaluation of marginal land and its cost structure for suitability for coppice development without irrigation.
7. Determination of varying mechanisms for scaling up production within minimum time frame to provide a sustainable feedstock.
8. Investigate ways to modify coppice cycle lengths to maintain the supply as coppice crops transitions between cutting cycles. The initial 2-year harvest produces a much lower yield than subsequent 4-year cutting cycle harvests. The final cutting cycle harvest is slightly lower due to the declining vigor of the rootstock. Regulating a sustainable supply from a fixed land area will require alterations in the cutting cycles.

5.3.8.1 Future Prospects

Dedicated bioenergy plantations offer a mechanism for providing supplementary fiber supply for bio-refineries. The evaluation of bioenergy plantations has not incorporated the synergies achieved by blending with other fiber supplies, the cost savings from increased operation scale, or the prospects of increased growth rates and drought tolerance achievable through continued hybridization and varietal development.

As energy prices increase, biomass fiber demands increase, technology improves, and tree improvements advance, the viability will likely expand into progressively more marginal sites, and the financial performance of dedicated bioenergy plantations will progressively improve.

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Natural Resource Conservation Service | Soil Descriptions for Lake County and Flathead Valley, MT

TOP THREE SOILS, BY AREA, IN THE LAKE COUNTY AREA, NEAR MISSOULA, MT (44% OF AVAILABLE LANDS)

Lake County Area, Montana
130—Polson silt loam
26% of available lands

Map Unit Setting
- Elevation: 2,400 to 3,500 feet
- Mean annual precipitation: 14 to 19 inches
- Mean annual air temperature: 39 to 45 degrees F
- Frost-free period: 105 to 135 days

Map Unit Composition
- Polson and similar soils: 85 percent
- Minor components: 15 percent

Description of Polson Setting
- Landform: Alluvial fans, stream terraces
- Down-slope shape: Linear
- Across-slope shape: Linear
- Parent material: Glaciofluvial deposits

Properties and qualities
- Slope: 0 to 2 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Well drained
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Calcium carbonate, maximum content: 15 percent
- Maximum salinity: Very slightly saline to slightly saline (4.0 to 8.0 mmhos/cm)
- Sodium adsorption ratio, maximum: 30.0
- Available water capacity: Moderate (about 8.7 inches)

Interpretive groups
- Farmland classification: Farmland of local importance
- Land capability classification (irrigated): 3s
- Land capability (nonirrigated): 3s
- Hydrologic Soil Group: C

Typical profile
- 0 to 10 inches: Silt loam
- 10 to 18 inches: Silt loam
- 18 to 60 inches: Silt loam

Lake County Area, Montana
63—Gird silt loam
10% of available lands

Map Unit Setting
- Elevation: 2,300 to 4,300 feet
- Mean annual precipitation: 14 to 22 inches
- Mean annual air temperature: 39 to 45 degrees F
- Frost-free period: 105 to 135 days

Map Unit Composition
- Gird and similar soils: 85 percent
- Minor components: 15 percent

Description of Gird Setting
- Landform: Alluvial fans, stream terraces
- Down-slope shape: Linear
- Across-slope shape: Linear
- Parent material: Glaciofluvial deposits

Properties and qualities
- Slope: 0 to 2 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Well drained
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Calcium carbonate, maximum content: 10 percent
- Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
- Available water capacity: High (about 10.3 inches)

Interpretive groups
- Farmland classification: Prime farmland if irrigated
- Land capability classification (irrigated): 2e
- Land capability (nonirrigated): 3e
- Hydrologic Soil Group: B

Typical profile
- 0 to 10 inches: Silt loam
- 10 to 17 inches: Silt loam
- 17 to 60 inches: Silt loam

Lake County Area, Montana
95—Lonepine silt loam
8% of available lands

Map Unit Setting
- Elevation: 2,000 to 3,500 feet
- Mean annual precipitation: 10 to 19 inches
- Mean annual air temperature: 39 to 45 degrees F
- Frost-free period: 105 to 135 days

Map Unit Composition
- Lonepine and similar soils: 85 percent
- Minor components: 15 percent

Description of Lonepine Setting
- Landform: Lake plains
- Down-slope shape: Linear
- Across-slope shape: Linear
- Parent material: Lacustrine deposits

Properties and qualities
- Slope: 2 to 4 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Well drained
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Calcium carbonate, maximum content: 15 percent
- Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
- Available water capacity: High (about 10.9 inches)

Interpretive groups
- Farmland classification: Prime farmland if irrigated
- Land capability classification (irrigated): 2e
- Land capability (nonirrigated): 3e
- Hydrologic Soil Group: C
- Ecological site: Silty (Si) 10-14” p.z. (R044XW125MT)

Typical profile
- 0 to 6 inches: Silt loam
- 6 to 14 inches: Silt loam
- 14 to 60 inches: Silt loam

TOP THREE SOIL SERIES, BY AREA, IN THE FLATHEAD VALLEY AREA, COLUMBIA FALLS TO KALISPELL, MT (41% OF AVAILABLE LANDS)

Upper Flathead Valley Area, Montana
So—Swims silt loam
18% of available lands

Map Unit Setting
- Elevation: 2,600 to 3,400 feet
- Mean annual precipitation: 15 to 18 inches
- Mean annual air temperature: 39 to 45 degrees F
- Frost-free period: 100 to 120 days

Map Unit Composition
- Swims and similar soils: 90 percent
- Minor components: 10 percent

Description of Swims Setting
- Landform: Terraces
- Down-slope shape: Linear
- Across-slope shape: Linear
- Parent material: Alluvium

Properties and qualities
- Slope: 0 to 3 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Moderately well drained
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
- Depth to water table: About 48 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Calcium carbonate, maximum content: 15 percent
- Maximum salinity: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)
- Available water capacity: High (about 10.2 inches)

Interpretive groups
- Farmland classification: Prime farmland if irrigated
- Land capability classification (irrigated): 3e
- Land capability (nonirrigated): 3e
- Hydrologic Soil Group: B

Typical profile
- 0 to 1 inches: Slightly decomposed plant material
- 1 to 5 inches: Silt loam
- 5 to 12 inches: Silty clay loam
- 12 to 26 inches: Silt loam
- 26 to 55 inches: Stratified very fine sandy loam to silty clay loam
- 55 to 60 inches: Loamy fine sand

Upper Flathead Valley Area, Montana
Kze—Kiwanis loam
13% of available lands

Map Unit Setting
- Elevation: 3,000 to 5,000 feet
- Mean annual precipitation: 12 to 17 inches
- Mean annual air temperature: 39 to 45 degrees F
- Frost-free period: 90 to 130 days

Map Unit Composition
- Kiwanis and similar soils: 90 percent
- Minor components: 10 percent

Description of Kiwanis Setting
- Landform: Stream terraces
- Down-slope shape: Linear
- Across-slope shape: Linear
- Parent material: Alluvium

Properties and qualities
- Slope: 0 to 3 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Well drained
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Calcium carbonate, maximum content: 10 percent
- Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
- Available water capacity: Moderate (about 6.7 inches)

Interpretive groups
- Farmland classification: Prime farmland if irrigated
- Land capability classification (irrigated): 3e
- Land capability (nonirrigated): 3e
- Hydrologic Soil Group: B
- Ecological site: Silty (Si) 15-19” p.z. (R044XW184MT)

Typical profile
- 0 to 9 inches: Loam
- 9 to 39 inches: Fine sandy loam
- 39 to 70 inches: Very gravelly sand

Upper Flathead Valley Area, Montana
Wp—Walters very fine sandy loam
10% of available lands

Map Unit Setting
- Mean annual precipitation: 15 to 19 inches
- Mean annual air temperature: 37 to 43 degrees F
- Frost-free period: 90 to 130 days

Map Unit Composition
- Walters and similar soils: 90 percent
- Minor components: 10 percent

Description of Walters Setting
- Landform: Terraces
- Down-slope shape: Linear
- Across-slope shape: Linear
- Parent material: Alluvium

Properties and qualities
- Slope: 0 to 7 percent
- Depth to restrictive feature: More than 80 inches
- Drainage class: Well drained
- Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Calcium carbonate, maximum content: 5 percent
- Available water capacity: Moderate (about 6.2 inches)

Interpretive groups
- Farmland classification: Farmland of statewide importance
- Land capability classification (irrigated): 4e
- Land capability (nonirrigated): 4e
- Hydrologic Soil Group: B

Typical profile
- 0 to 2 inches: Slightly decomposed plant material
- 2 to 12 inches: Very fine sandy loam
- 12 to 15 inches: Silt loam
- 15 to 26 inches: Fine sandy loam
- 26 to 38 inches: Fine sandy loam
- 38 to 60 inches: Stratified sand to gravelly coarse sand

5.3.11 APPENDIX II

Activities for Western Montana Corridor Bioenergy Planting - Current or Former Ag Lands

Table 5.3.6. Year 0 - year before planting

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
June	Contact herbicide for vegetation control	100%	$40.00	$40.00	$40.00
July	Heavy disk	100%	$40.00	$40.00	$40.00
August	Finish disk and smooth	100%	$25.00	$25.00	$25.00
September	Row marking/riping	100%	$25.00	$25.00	$25.00
September	Fertilizer application (at time of ripping)	100%	$35.00	$35.00	$0.00
September	Irrigation tube layout (optional)	100%	$15.00	$0.00	$15.00
September	Herbicide - contact plus preemergent	100%	$55.00	$55.00	$55.00
			Subtotal	$220.00	$200.00

Table 5.3.7. Year 1 - the year of planting

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
January	Purchase plant material (unrooted cuttings)		$377.00	$377.00	$377.00
April	Herbicide - contact plus preemergent	100%	$55.00	$55.00	$55.00
April	Fertilizer application (drip-in, optional)	100%	$25.00	$0.00	$25.00
May	Irrigation start up (optional)	100%	$8.00	$0.00	$8.00
May	Plant cuttings	100%	$87.00	$87.00	$87.00
June	Between row cultivation	100%	$30.00	$30.00	$30.00
June	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
August	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
September	Irrigation cost (12 acre inches)	100%	$60.00	$0.00	$60.00
September	Between row cultivation	100%	$30.00	$30.00	$30.00
			Subtotal	$619.00	$712.00

Table 5.3.8. Year 2 - maintain the crop, initial harvest

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
April	Herbicide - along row preemergent	100%	$55.00	$55.00	$55.00
May	Irrigation start up (optional)	100%	$8.00	$0.00	$8.00
May	Fertilizer application (drip-in, optional)	100%	$25.00	$0.00	$25.00
May	Between row cultivation	100%	$30.00	$30.00	$30.00
July	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
August	Between row cultivation	25%	$55.00	$13.75	$13.75
August	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
September	Between row cultivation	100%	$30.00	$30.00	$30.00
September	Irrigation cost (14 acre inches)	100%	$70.00	$0.00	$70.00
September	Remove irrigation components (optional)	100%	$15.00	$0.00	$15.00
October	Harvest & transport to field edge	100%	$249.53	$249.53	$249.53
			Subtotal	$418.28	$536.28

Table 5.3.9. Years 3, 7, 11, 15, and 19 - first year of coppice

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
April	Herbicide - along row preemergent	100%	$55.00	$55.00	$55.00
April	Fertilizer application (banded, dry)	100%	$45.00	$45.00	$0.00
May	Irrigation tube layout and start up (optional)	100%	$23.00	$0.00	$23.00
May	Fertilizer application (drip-in, optional)	100%	$25.00	$0.00	$25.00
May	Between row cultivation	100%	$30.00	$30.00	$30.00
July	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
August	Pest control (only as needed)	25%	$55.00	$13.75	$13.75
August	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
September	Irrigation cost (14 acre inches)	100%	$70.00	$0.00	$70.00
September	Between row cultivation	100%	$30.00	$30.00	$30.00
			Subtotal	$213.75	$286.75

Table 5.3.10. Years 4, 8, 12, 16, and 20 - second year of coppice

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
April	Herbicide - along row preemergent	100%	$55.00	$55.00	$55.00
May	Irrigation start up (optional)	100%	$8.00	$0.00	$8.00
May	Fertilizer application (drip-in, optional)	100%	$25.00	$0.00	$25.00
May	Between row cultivation	100%	$30.00	$30.00	$30.00
July	Along row spot spray or manual weeding	33%	$40.00	$13.20	$13.20
August	Pest control (only as needed)	25%	$55.00	$13.75	$13.75
August	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
September	Irrigation cost (16 acre inches)	100%	$80.00	$0.00	$80.00
September	Between row cultivation	100%	$30.00	$30.00	$30.00
			Subtotal	$161.95	$274.95

Table 5.3.11. Years 5, 9, 13, 17, and 21 - third year of coppice

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
May	Irrigation start up (optional)	100%	$8.00	$0.00	$8.00
May	Fertilizer application (drip-in, optional)	100%	$30.00	$0.00	$30.00
July	Along row spot spray or manual weeding	50%	$40.00	$20.00	$20.00
August	Pest control (only as needed)	25%	$55.00	$13.75	$13.75
September	Irrigation cost (18 acre inches)	100%	$90.00	$0.00	$90.00
			Subtotal	$33.75	$161.75

Table 5.3.12. Years 6, 10, 14, 18, and 22 - fourth year of coppice

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
May	Irrigation start up (optional)	100%	$8.00	$0.00	$8.00
May	Fertilizer application (drip-in, optional)	100%	$30.00	$0.00	$30.00
August	Pest control (only as needed)	25%	$55.00	$13.75	$13.75
September	Irrigation cost (18 acre inches)	100%	$90.00	$0.00	$90.00
September	Remove irrigation components (optional)	100%	$15.00	$0.00	$15.00
October	Harvest & transport to field edge	100%	$569.77	$569.77	$569.77
			Subtotal	$583.52	$726.52

Table 5.3.13. Year 23 - year before planting, post-harvest site preparation

Month	Activity	Percent of Area	Cost per Acre	Cost w/no irrigation	Cost w/ irrigation
June	Contact herbicide for vegetation control	100%	$40.00	$40.00	$40.00
July	Heavy Disk	100%	$55.00	$55.00	$55.00
August	Finish disk and smooth	100%	$45.00	$45.00	$45.00
September	Row marking	100%	$30.00	$30.00	$30.00
September	Irrigation tube layout (optional)	100%	$15.00	$0.00	$15.00
September	Herbicide - contact plus preemergent	100%	$50.00	$50.00	$50.00
			Subtotal	$220.00	$235.00

5.3.12 APPENDIX III

Results of Hybrid Poplar Clonal Test at Kalispell, Montana

Table 5.3.14. Results of hybrid poplar clonal test at Kalispell, MT

Region	Taxon	Mean Height (ft)	Mean Survival (%)	Number of Clones	Top Height (ft)	Top Survival (%)	MAI of Top Clones (BDT)
PNW	DxM	13.8	85	4	15.2	100	
PNW	DxN	19.2	80	34	26.7	100	3.7
PNW	DxT	16.7	67	4	22.3	100	
PNW	TxN	13.8	83	1	13.8	83	
NC	NxM	17.9	92	1	17.9	92	
NC	NxT	19.8	100	2	21.3	100	
NC	TxD	27.1	88	2	28.5	100	4.0
NC	Dx(TD)	19.6	44	3	22.9	58	
NC	DxM	21.1	78	8	26.3	100	3.7
NC	DxN	26.8	96	32	34.7	100	4.6
NC	TDx(D)	21.8	0.67	5	25.8	1.00	

5.3.13 APPENDIX IV

Predicted Harvest Yields for Hybrid Poplar Bioenergy Plantings in the WMC

Table 5.3.15.

High site, irrigated				
Harvest Age	Description	Total Green Tons Per Acre	Total Bone Dry Tons (BDT's) Per Acre	Mean Annual Increment (BDT's Per Acre)
2	Initial planting harvest	16.3	7.0	3.5
6	1st Coppice Harvest	45.6	19.6	4.9
10	2nd Coppice Harvest	45.6	19.6	4.9
14	3rd Coppice Harvest	45.6	19.6	4.9
18	4th Coppice Harvest	45.6	19.6	4.9
22	5th Coppice Harvest	41.0	17.6	4.4

Table 5.3.16.

High site, non-irrigated				
Harvest Age	Description	Total Green Tons Per Acre	Total Bone Dry Tons (BDT's) Per Acre	Mean Annual Increment (BDT's Per Acre)
2	Initial planting harvest	14.0	6.0	3.0
6	1st Coppice Harvest	42.8	18.4	4.6
10	2nd Coppice Harvest	42.8	18.4	4.6
14	3rd Coppice Harvest	42.8	18.4	4.6
18	4th Coppice Harvest	42.8	18.4	4.6
22	5th Coppice Harvest	38.2	16.4	4.1

Table 5.3.17.

Low site, irrigated				
Harvest Age	Description	Total Green Tons Per Acre	Total Bone Dry Tons (BDT's) Per Acre	Mean Annual Increment (BDT's Per Acre)
2	Initial planting harvest	11.2	4.8	2.4
6	1st Coppice Harvest	36.3	15.6	3.9
10	2nd Coppice Harvest	36.3	15.6	3.9
14	3rd Coppice Harvest	36.3	15.6	3.9
18	4th Coppice Harvest	36.3	15.6	3.9
22	5th Coppice Harvest	31.7	13.6	3.4

Table 5.3.18.

Low site, non-irrigated				
Harvest Age	Description	Total Green Tons Per Acre	Total Bone Dry Tons (BDT's) Per Acre	Mean Annual Increment (BDT's Per Acre)
2	Initial planting harvest	9.8	4.2	2.1
6	1st Coppice Harvest	30.2	13.0	3.3
10	2nd Coppice Harvest	30.2	13.0	3.3
14	3rd Coppice Harvest	30.2	13.0	3.3
18	4th Coppice Harvest	30.2	13.0	3.3
22	5th Coppice Harvest	25.7	11.0	2.8

5.3.14 APPENDIX V

Plantation Development Management & Operation Areas - Base Case Scenario

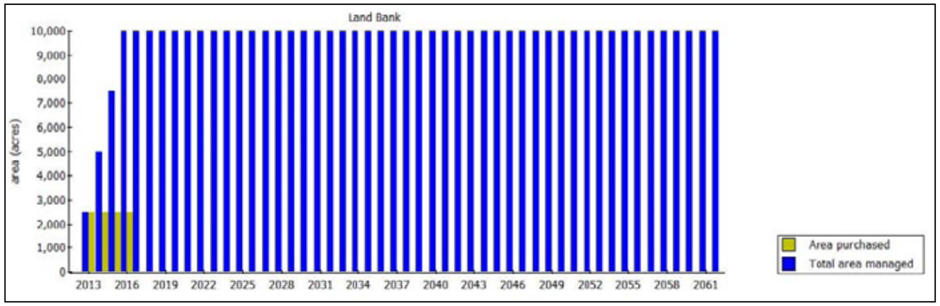

Figure 5.3.2 Land Bank

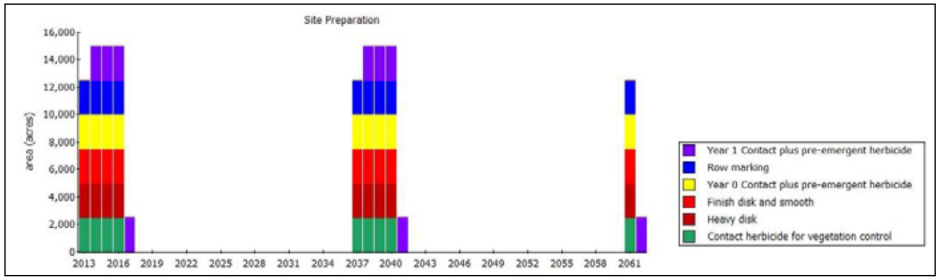

Figure 5.3.3. Site Preparation

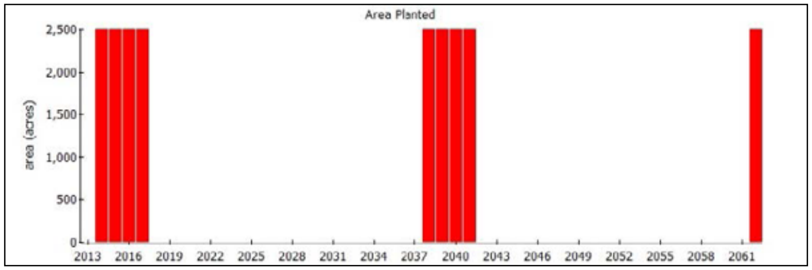

Figure 5.3.4. Area Planted

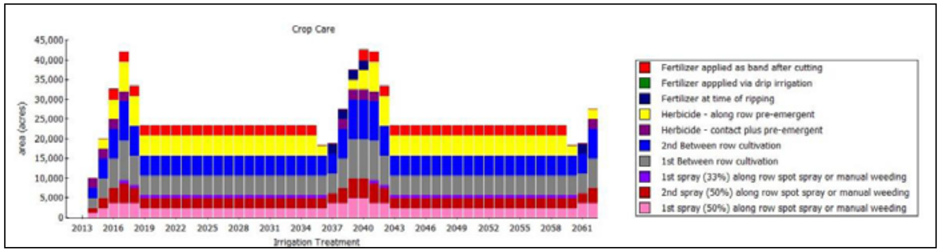

Figure 5.3.5. Crop Care

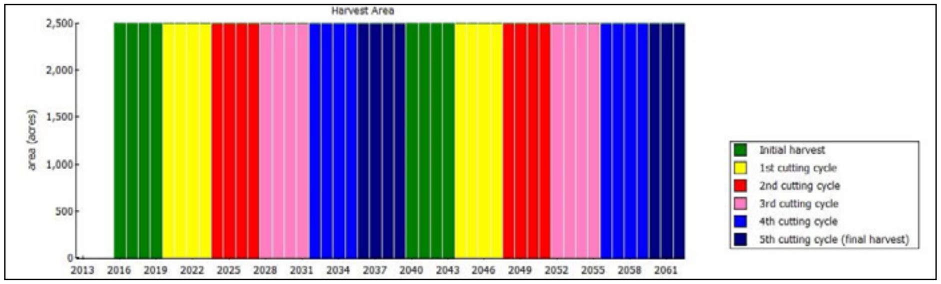

Figure 5.3.6. Harvest Area

Plantation Production Levels - Base Case Scenario

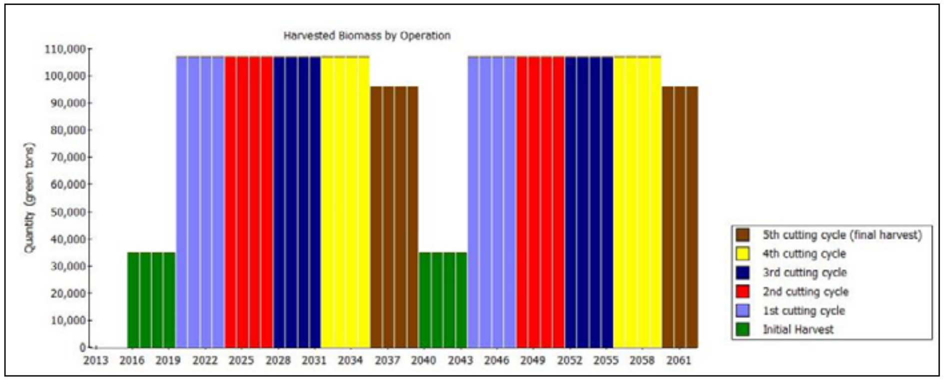

Figure 5.3.7. Harvested biomass by operation

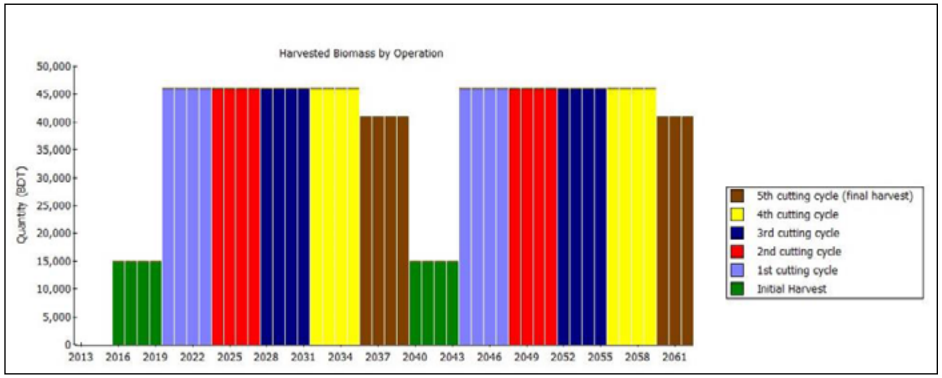

Figure 5.3.8. Harvested Biomass by operation

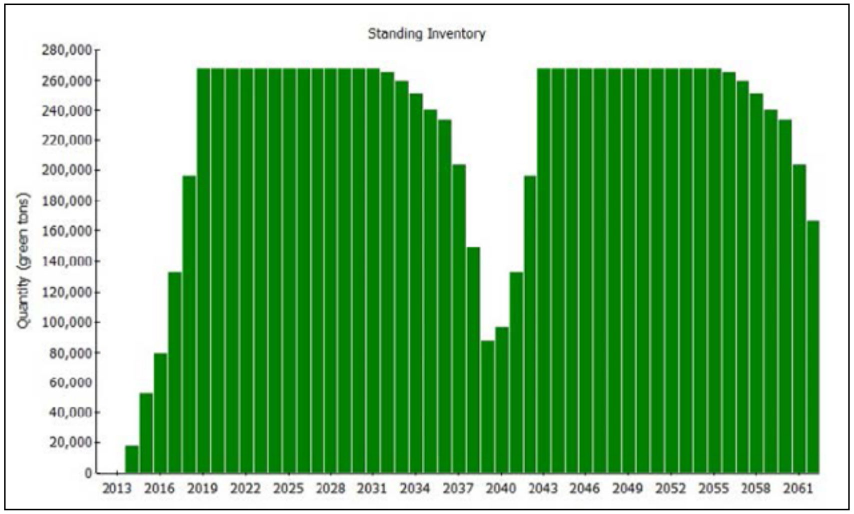

Figure 5.3.9. Standing inventory

Plantation Development and Management Direct Expenditure Profiles - Base Case Scenario

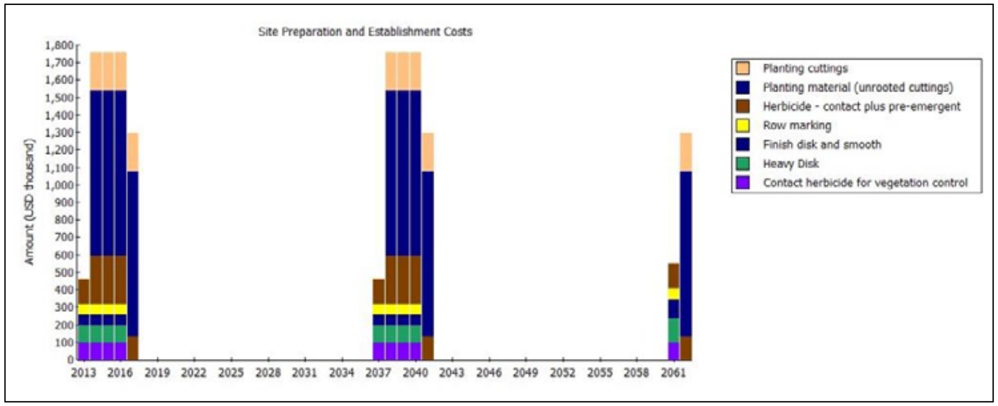

Figure 5.3.10. Site preparation and establishment costs

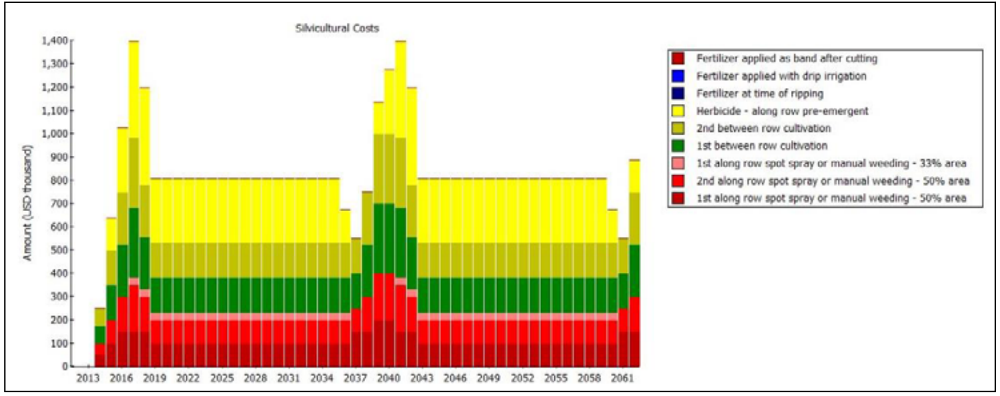

Figure 5.3.11. Silvicultural Costs

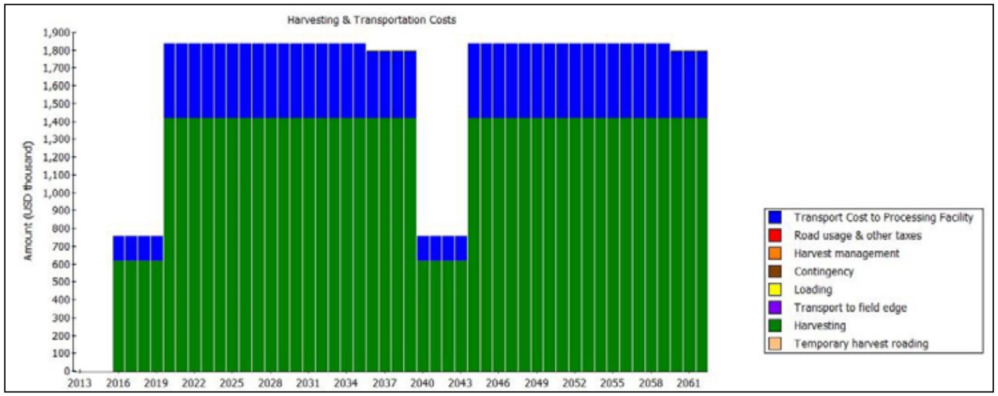

Figure 5.3.12. Harvesting and transportation costs

Plantation Development and Management Indirect Expenditure Profiles - Base Case Scenario

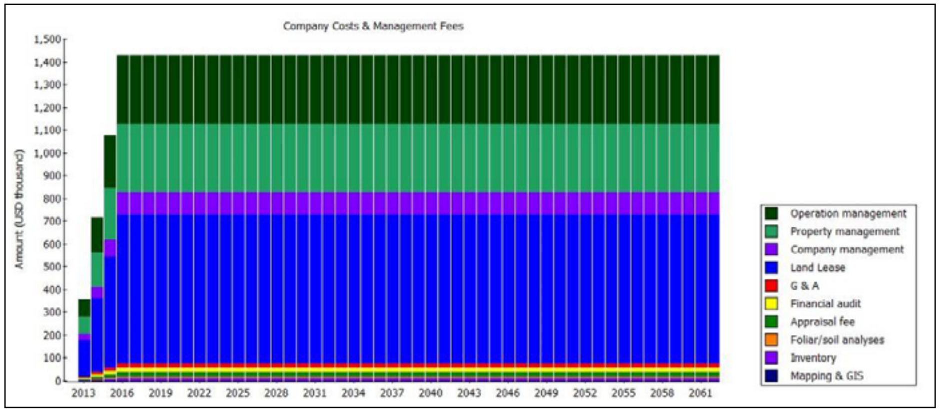

Figure 5.3.13. Company costs and management fees

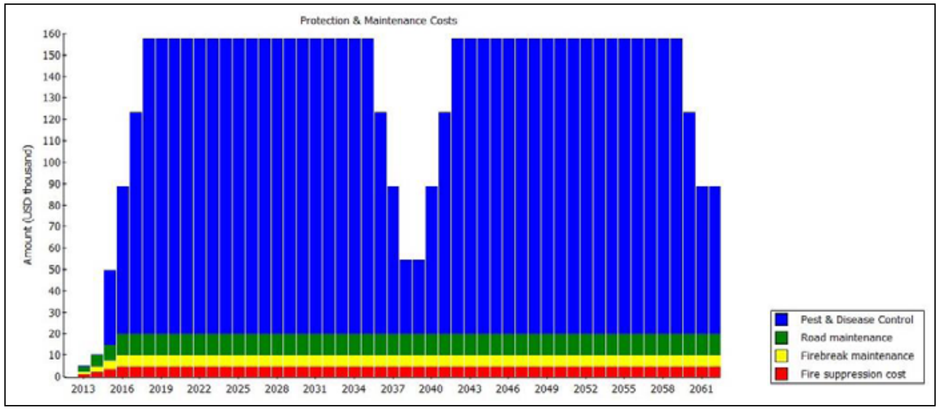

Figure 5.3.14. Protection and maintenance costs

Plantation Net Cashflow Profile (Break-even market price $115/BDT) - Base Case Scenario

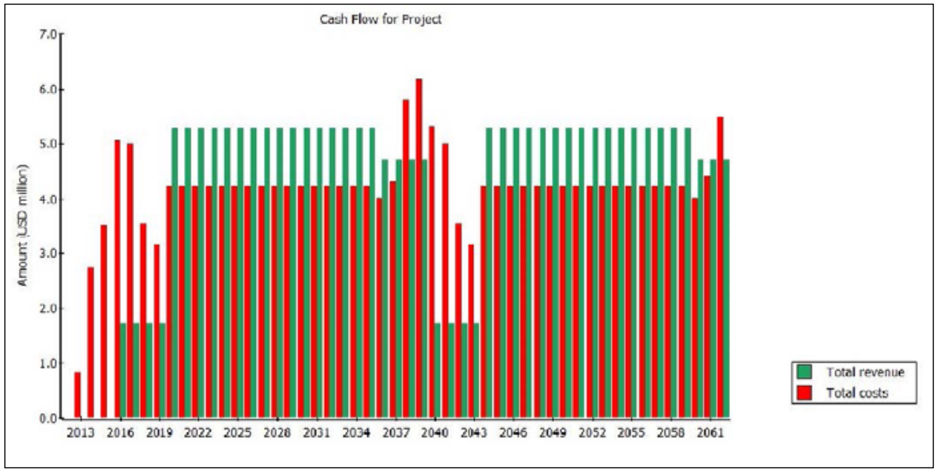

Figure 5.3.15. Cash flow for project

5.4.0 BIOMASS SUPPLY ESTIMATES FOR THE CONFEDERATED SALISH AND KOOTENAI TRIBES BASED ON HARVEST PLANNING AND MANAGEMENT GOALS

UNIVERSITY OF WASHINGTON
Blake R. Hough
Daniel T. Schwartz
Laurel James

Introduction and Background

A mix of economic, policy, and social forces are pushing us to increase the use of forest residues from managed timberlands. In this report the terms forest residue and slash are used interchangeably and refer to any woody material left at the site of a timber harvest or thinning operation. Typically these materials are burned in slash piles in the forest to reduce the available fuel for wildfires. Assessment of forest biomass residues is therefore increasingly important for determining the viability of bioenergy projects, understanding the fire-related characteristics of forest to help in wildfire prevention and decision making, and studying the effects of changing forest conditions on the carbon cycle and global climate change.

Nearly all biomass assessment strategies that quantify the amount of available forest residues rely on regional data from mills or other wood processing facilities, or from FIA (Forest Inventory Analysis program) plot data. FIA data characterizes forests in the U.S. using aerial and satellite imagery, as well as field measurements (one sample site per 6,000 acres)[1]. Information from either mills or FIA is generally used to determine how much timber is available within a county or state, and what the "average" stand characteristics (forest structure, mix of species, tree sizes, etc.) in that region are. Such regional stand characteristics are input to a software program that simulates forest growth. Then, the volume of forest residue available can be determined using:

- regional conversion factors for volume of slash per volume of delivered timber[2,3,4,5,6]
- allometric equations based on characteristics of the harvested trees[7]
- or allometric equations based on characteristics of the entire stand[8]

In rare cases biomass assessments use alternative strategies such as calculating the total volume of forest residue based on a percentage of the annual allowable cut[9], or taking actual measurements of the forest, and slash piles, pre- and post-harvest across a harvest site[10,11]. The predictive capability of these alternative strategies is generally not applicable outside the local region studied.

As described above, assessment of biomass supply chains often takes place on the regional scale, usually applying regional average conversion factors to estimate available biomass. These regional conversion factors are based on historical harvest practices and volumes, and they cannot be used to assess what is actually on the landscape if the landowner's harvest practices differ significantly from the regional norm. Assessing the available biomass when ecologically based forest management takes place (different from conventional industrial forestry) requires more detailed knowledge of the distribution and composition of forest resources. We are working with the Confederated Salish and Kootenai Tribes (CSKT) to assess the availability and costs of collecting slash from planned forest management activities. Our estimates are based on detailed landscape-level information of the forest composition and actual CSKT harvest strategies.

CSKT's Forest Management Plan[12] outlines 12 goals for the management of Tribal forests:

1. Strengthen Tribal sovereignty and self-sufficiency through good forest management.
2. Manage forest ecosystems to include natural processes and to balance cultural, spiritual, economic, social and environmental values.
3. Adopt a process which accommodates changes in Tribal values and resources.
4. Facilitate Tribal member involvement in forest stewardship.
5. Provide sustained yield of forest products and maintain or enhance forest health.
6. Develop options for managing land use conflicts.
7. Provide perpetual economic benefits of labor, profit, and products to local communities.
8. Manage forested ecosystems to protect and enhance biological diversity.
9. Provide a variety of natural areas that Tribal members can use for solitude, cultural activities, and recreation pursuits.
10. Work cooperatively with adjacent landowners and federal agencies to minimize cumulative impacts.
11. Protect human life, property and forest resources through fire suppression and fuels management.
12. Comply with Tribal and Federal laws.

To meet these goals, Tribal foresters use an ecosystem-centered approach to managing their forests that differs from more typical industrial forestry, which focuses most on economic benefits. CSKT foresters have developed two ecological descriptors to aid in prescribing management strategies: fire regimes and seral clusters.

A *fire regime* refers to the type of fire behavior that occurred on the landscape during pre-European times. They reveal basic information about how the ecosystem functioned before fire suppression. Five fire regimes have been defined by the Tribes based on fire frequency, fire intensity, and the pattern of vegetation that fires create.

Seral clusters are another ecological descriptor defined by the Tribes. A seral cluster describes the structure and composition of the forest – the size and age of trees, how close they are to each other, whether stands are single- or multi-layered, and whether species are shade tolerant or intolerant. A stands seral cluster also provides information about fire risk and severity, cover for big game, habitat for insects and birds, and risk of disease. Twelve seral clusters, A-L, are defined by the Forest Management Plan.

Silvicultural treatments on the reservation are ecologically determined by the seral cluster and fire regime at the harvest location.

When modeling the Tribal forest resources we used data from 296 Continuous Forest Inventory (CFI) plots from across the forested areas of the reservation (Figure 4.1.1). CFI is a forest sampling system that periodically re-measures specific forest stands or plots of individual trees to record how the forest changes over time. In each CFI plot the size, species, and structure of every tree on a 1/5 acre plot of land is recorded. Our CFI plot data is from 1999.

Table 4.1.1. An annual allowable cut of 18.1MMBF (million board feet) is set forth in the Forest Management Plan and this is the annual harvest volume we use in our analysis

Acronyms:	
AAC	Annual Allowable Cut
CFI	Continuous Forest Inventory
CSKT	The Confederated Salish & Kootenai Tribes
DBH	Diameter at breast height
FVS	The Forest Vegetation Simulator
GIS	Geographic Information System
MMBF	Million Board Feet

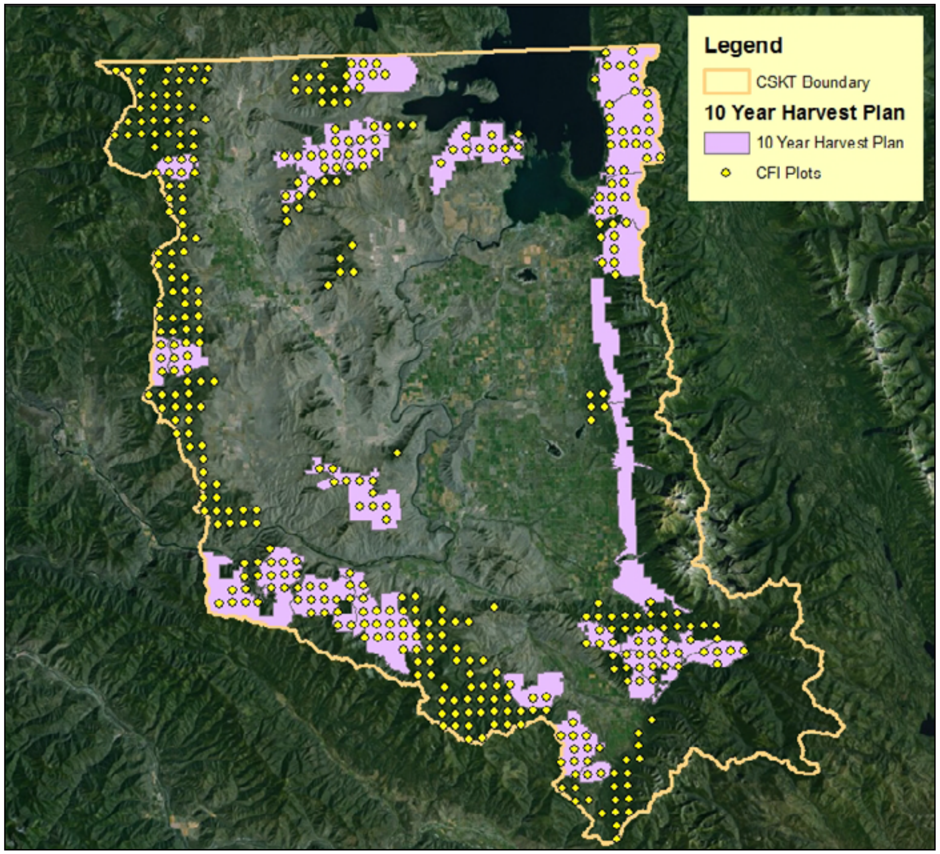

Figure 4.1.1. CFI plots on the reservation are shown with the planned harvest areas for the next 10 years

1 http://www.fia.fs.fed.us/
2 Morgan, T. An Assessment of Forest-based Woody Biomass Supply and Use in Montana. Report for Montana Department of Natural Resources and Conservation. Missoula (MT): 2009.
3 Fitzpatrick, J. et al. Developing a Business Case for Sustainable Biomass Generation: A Regional Model for Western Montana. Report for NorthWestern Energy (2010).
4 Howard, J. Ratios for Estimating Logging Residue in the Pacific Northwest. Research Paper PNW-288. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station (1981).
5 Richardson, J. J. et al. Uncertainty in biomass supply estimates: Lessons from a Yakama Nation case study. Biomass and Bioenergy 35, 3698–3707 (2011).
6 Skog, K. et al. Forest-Based Biomass Supply Curves for the United States. J. Sustain. For. 32, 14–27 (2013).
7 Perez-Garcia, J. et al. Washington Forest Biomass Supply Assessment. Report for Washington Department of Natural Resources. Seattle (WA): 2012.
8 Rørstad, P. K., Trømborg, E., Bergseng, E. & Solberg, B. Combining GIS and Forest Modelling in Estimating Regional Supply of Harvest Residues in Norway. Silva Fenn. 44, 435–451 (2010).
9 Cozzi, M., Di Napoli, F., Viccaro, M. & Romano, S. Use of Forest Residues for Building Forest Biomass Supply Chains: Technical and Economic Analysis of the Production Process. Forests 4, 1121–1140 (2013).
10 Alam, B., Pulkki, R. & Shahi, C. Woody biomass availability for bioenergy production using forest depletion spatial data in northwestern Ontario. Can. J. For. Res. 516, 506–516 (2012).
11 Bouriaud, O., Ştefan, G. & Flocea, M. Predictive models of forest logging residues in Romanian spruce and beech forests. Biomass and Bioenergy 54, 59–66 (2013).
12 Available at http://www.cskt.org/documents/forestry/fmp05.pdf

FVS Analysis

We worked with Tom Richards at Northwest Management, Inc. to simulate the growth and projected harvests from 296 CFI plots on the CSKT reservation using the Forest Vegetation Simulator (FVS). FVS is a set of forest growth simulation models provided by the US Forest Service[13] that can predict how the forest will change as a result of natural growth and proposed management activities. The tool is based on decades of forestry research and experience and it is widely used in the natural resource industry.

This project used the Expanded Inland Empire variant of FVS version 0979. Key input settings are described in the appendix. FVS Simulations were run on all 296 CFI plots provided by CSKT, representing each defined seral cluster. The prescriptions in Table 4.1.2, provided by Tribal foresters, define the harvest treatments for different seral clusters in FVS.

We defined merchantable wood as any harvested bole wood between a one foot stump height and a four inch diameter top from trees with DBH's over seven inches. Defect ratios are applied based on tree size as defined in Table 4.1.3. The simulations predict the amount of merchantable wood (board feet/acre) harvested from stands of each seral type, broken down by tree species, and we used that information to calculate slash volumes as described in the next section.

Table 4.1.3. Defect and breakage losses during harvest. The simulations predict the amount of merchantable wood (board feet/acre) harvested from stands of each seral type, broken down by tree species, and we used that information to calculate slash volumes as described in the next section.

DBH (inches)	Loss from defect & breakage (%)
5	5
10	5
15	7
20	7
25	10
30	11
35	12
40+	13

Table 4.1.2. Silvicultural Treatment Matrix, provided by Tribal foresters, define the harvest treatments for different seral clusters in FVS.

Seral Cluster	Fire Regime				
	Encroachment	Non-Lethal	Mixed Severity	Lethal	High Elevation
A_0, A_1	No Harvest	No Harvest	No Harvest	No Harvest	No Harvest
A_2	No Harvest	No Harvest	No Harvest	No Harvest	No Harvest
B & C	No Harvest	Pre-Commercial Thin – 300 TPA	Pre-Commercial Thin – 300 TPA	Pre-Commercial Thin – 300 TPA	No Harvest
D	No Harvest	Commercial Thin – 300 TPA	Commercial Thin – 300 TPA	Even-Aged Clearcut – 20% of area	No Harvest
E & I	No Harvest	Even-aged Clearcut – 20% of area	Even-Aged Clearcut – 20% of area	Even-Aged Clearcut – 20% of area	No Harvest
F	No Harvest	Uneven-aged Q of 1.1 – to 45 BA	Uneven-aged Q of 1.1 – to 60 BA	Even-Aged Seed Tree – 20% of area	No Harvest
G	No Harvest	Uneven-aged Q of 1.1 – to 45 BA	Even-Aged SW – 25% of area (30 BA), Uneven-aged – 50% of area (60 BA)	Even-Aged Seed Tree – 20% of area	Even-Aged Clearcut – 20% of area
H	No Harvest	No Harvest	No Harvest	Even-Aged Seed Tree – 20% of area	Even-Aged Clearcut – 20% of area
J	No Harvest	Thin from below to 70 BA	Uneven-aged Q of 1.1 – to 70 BA	Even-Aged Clearcut – 20% of area	Even-Aged Clearcut – 20% of area
K	No Harvest	Thin from below to 80 BA	Uneven-aged Q of 1.1 – to 80 BA	Even-Aged Clearcut – 20% of area	No Harvest
L	No Harvest	No Harvest	No Harvest	Even-Aged Clearcut – 20% of area	No Harvest

Slash Volume Estimation

FVS simulations predicted the volume of merchantable wood per acre that will be harvested and delivered to a mill for each seral cluster and year. Unfortunately FVS cannot directly predict the amount of slash that will be left on the landscape after a harvest. To estimate the amount of slash we worked with Todd Morgan, Erik Berg, and Eric Simmons from the Bureau of Business and Economic Research at the University of Montana. Todd and his team were able to use the Resources Planning Act (RPA) Timber Product Output (TPO) database[14] to estimate the volume of slash per board foot delivered for each tree species in our FVS output (Table 4.1.4.). The slash volume estimated here includes tops, limbs, and any defect or breakage left on the site (note that pulp wood is considered a merchantable product and is not included in slash, but if pulp market conditions are poor it could add to the total slash volume available).

The RPA TPO database is built using data collected from all wood-using mills in every state, along with on-the-ground studies of a cross-section of actual logging operations in each state to relate TPO from the mills to slash left behind. RPA TPO slash estimates used in this project were based on data from Western Montana.

Applying these slash estimates to the FVS output data results in an estimate of the total volume of slash generated per acre after harvesting stands of each seral cluster/fire regime combination. It should be noted that because the RPA TPO database only accounts for timber delivered to a mill, any slash generated from thinning of trees with a DBH less than seven inches is not included in our final predicted slash volume.

Table 4.1.4. Volume of slash remaining on the landscape per board foot of merchantable wood delivered to a mill.

Species	FIA Species Code	Slash (ft^3)/board foot delivered to mill
Western Red Cedar	242	0.0944
Ponderosa Pine	122	0.0868
Whitebark Pine	101	0.0739
Engelmann Spruce	093	0.0695
Aspen	746	0.0715
Douglas Fir	202	0.0667
True Firs (Grand & Subalpine)	017, 019	0.0841
Western Larch	073	0.0649
Lodgepole Pine	108	0.0700

GIS Analysis

To gain detailed landscape-level understanding of the managed forest resources on CSKT lands we used geographic information system (GIS) data covering Tribal lands. All GIS analysis was performed using ArcMap version 10.2.[15]

CSKT provided us with GIS layers for their scheduled forest management areas for the next 10 years (Figure 4.1.2), their logging road network, and the distribution of Tribally-defined seral clusters and fire regimes across the landscape. Each seral cluster/fire regime forest type will lead to a unique estimate of available slash after harvest. To determine the acreage of each seral cluster/fire regime designation required analysis of all the Tribal GIS data.

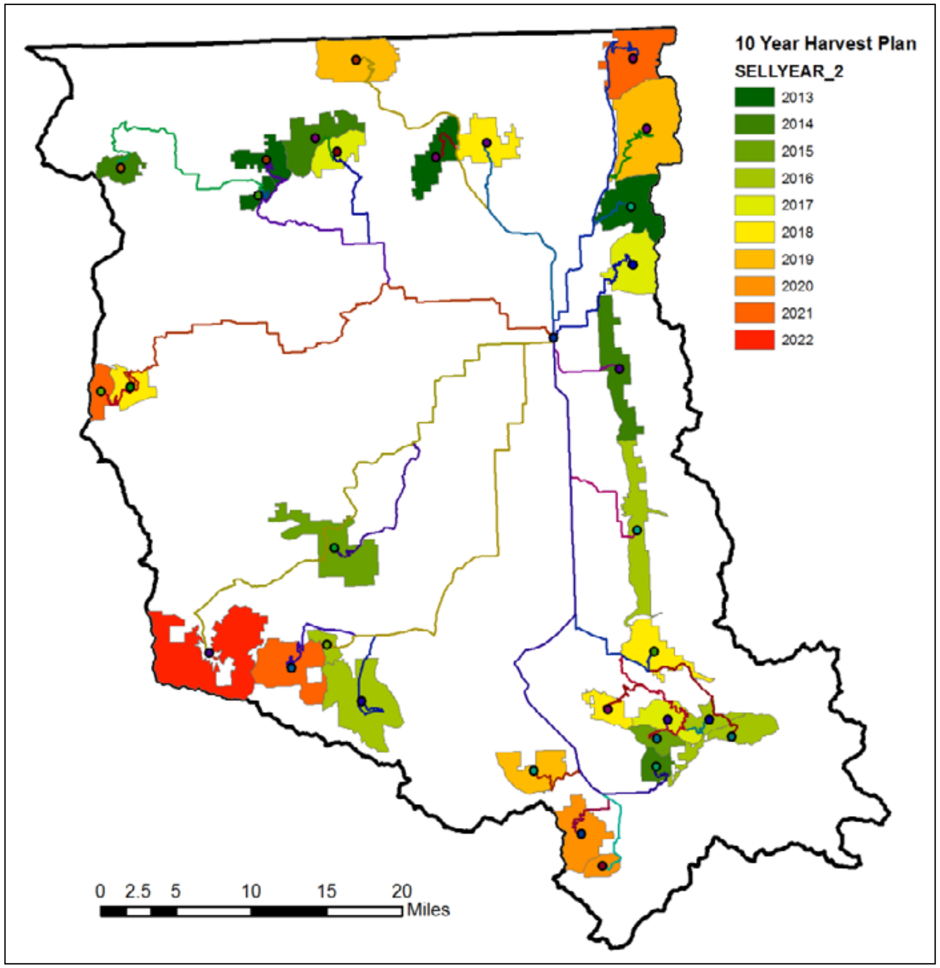

Figure 4.1.2. Forest management areas on the CSKT Reservation for the next 10 years. Roads connecting the centroid of each management area to a central facility in Pablo, MT

The Tribal road network layer (Figure 4.1.3) contains information on the quality and safe speed of each road. Based on this information and discussions with Tribal foresters we identified which roads are accessible by the articulated chip vans, which will be necessary to remove slash from the harvest areas (class 0-3 roads are assumed accessible).

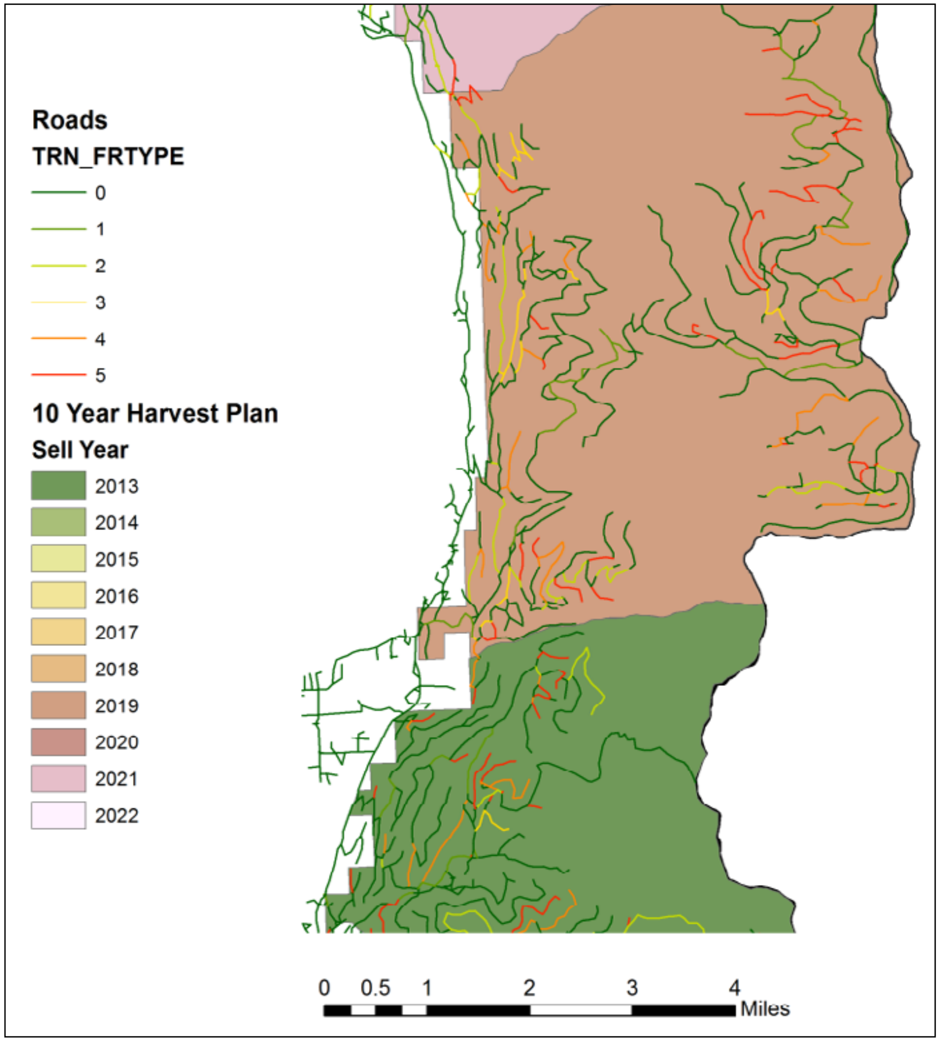

Figure 4.1.3. Sample harvest areas showing road class designations.

Around each chip van-accessible road we built a 400-foot buffer to define how far off the road harvesting operations will extend (Figure 4.1.4). 400 feet is an average harvest buffer distance provided by the Tribes based on their current harvest practices.

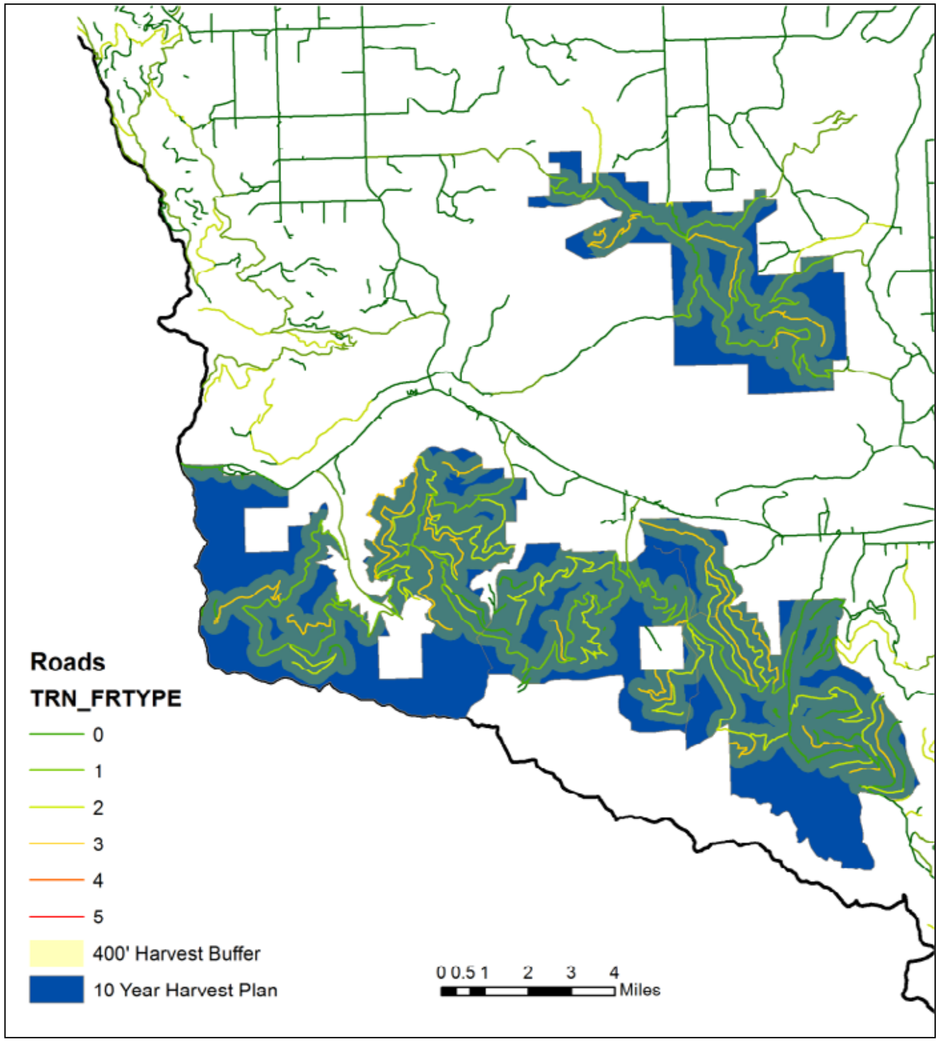

Figure 4.1.4. 400' harvest buffer applied around chip van-accessible roads within harvest areas. This defines the harvestable area where slash will be available to extract.

As described earlier, CSKT divides their forests into 13 structural classes, called seral clusters, describing tree size, stand density, species composition and layering. Five fire regimes area also defined based on the fire frequency, intensity, and pattern during the pre-European era. Computing the intersections of the seral cluster and fire regime GIS layers produced 50 new combined seral cluster/fire regime designators that can be mapped (Figure 4.1.5).

By combining the seral cluster/fire regime map with the 10 year harvest plan and harvest buffer zones we were able to extract the number of acres of each seral cluster/fire regime designation within each harvest area by year.

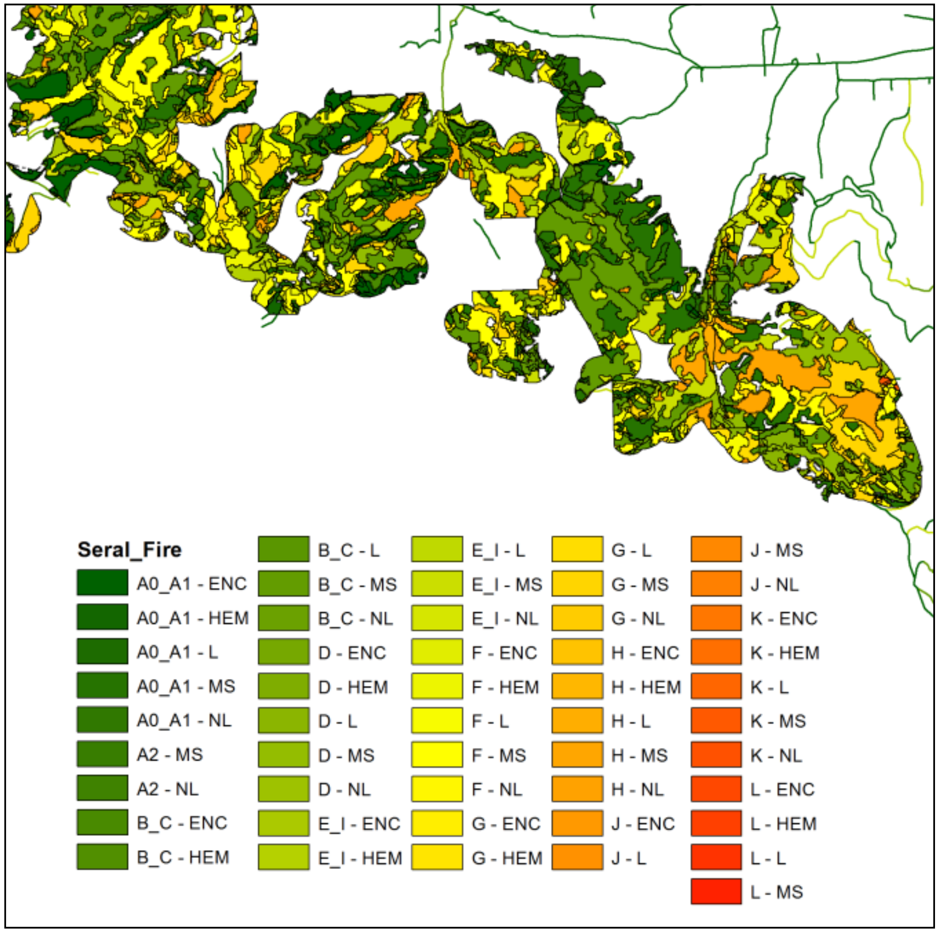

Figure 4.1.5. Seral cluster/fire regime designations describe all forested land on the reservation. Each designation has a different management strategy (resulting in different slash volumes), and mapping these within the harvest buffer zone gives the acreage and location of each seral/fire designation, allowing slash yield to be determined at specific locations.

Application of Slash Estimates to the CSKT Landscape and Transportation Analysis

In order to determine the predicted slash volume and board feet of timber harvested each year it was necessary to write a program that calculates the total acreage of each seral cluster/fire regime designation within a given harvest area and year, then apply the silviculturally specific slash and harvest estimates from FVS and the RPA TPO database.

For this initial analysis we have assumed that 65% of the total slash volume is recoverable for chipping and removal from the forest. This recovery factor was chosen because it is the value currently used by other NARA research groups, however we expect that the actual recoverable fraction may be much higher because harvest operations on CSKT lands often use whole-tree to landing harvesting techniques. A conversion factor of 0.015 BDT/ft3 was used to convert slash volumes from cubic feet to BDT[16].

In all but one year simulated, the total projected volume of harvestable timber exceeds the annual allowable cut of 18.1 MMBF. In order to remain within the AAC limit, the fraction of each harvest area where we allowed a computed harvest to occur was reduced until the number of board feet harvested equaled the AAC. The available fractions of all harvest areas for a given year were reduced by the same amount when making these adjustments.

To estimate the cost of delivering slash to a potential processing site in Pablo, MT we made the following assumptions, all based on input from Tribal foresters:

- Landings are located every quarter mile along logging roads
- Chip vans have a capacity of 30 BDT
- The cost to chip and load slash at a landing into a chip van is $8.90/BDT
- The cost to transport chips from the forest to Pablo is a flat rate of $3.50/mile
- The entire volume of slash from a given harvest area is evenly distributed over all landings in that harvest area (this results in an average of 40 BDT/landing)
- Chip vans pick up from only one landing before returning to Pablo, so they may not always be full

When calculating the cost of processing and transporting chips from a landing to Pablo the driving distance used was from the centroid of a harvest area to Pablo (see Figure 4.1.2).

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13 The Forest Vegetation Simulator (FVS) and related documentation are available at http://www.fs.fed.us/fmsc/fvs/

14 http://www.fia.fs.fed.us/program-features/tpo/

15 ESRI (Environmental Systems Resource Institute). 2013. ArcMap 10.2. ESRI, Redlands, California.

16 U.S. Department of Energy. 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p.

RESULTS

The results of our analysis on the availability of slash and cost to chip and deliver it to Pablo for the planned 10-year harvest schedule are shown in Table 4.1.5 (annual totals) and Table 4.1.7 (by harvest area).

Table 4.1.5. Total timber harvest and recoverable slash volumes

Year	Harvested Area (Acres)	Harvest (MMBF)	Recovered Slash (yd^3)	Recovered Slash (BDT)	Avg. Delivered Cost ($/BDT)
2013	11,049	18.1	31,966	12,946	16
2014	7,554	18.1	32,243	13,059	24
2015	10,431	18.1	31,992	12,957	21
2016	9,459	18.1	32,170	13,029	20
2017	8,822	18.1	32,283	13,075	17
2018	7,836	18.1	32,343	13,099	19
2019	9,482	18.1	32,266	13,068	20
2020	7,826	16.8	30,228	12,242	22
2021	9,541	18.1	32,364	13,108	20
2022	9,318	18.1	36,119	14,628	24

Our total annual slash volumes (predicted in Table 4.1.6) agree well with rough estimates of slash calculated using a general conversion factor for Montana of 1,096 BDT per 1 MMBF[17]:

Table 4.1.6.

Year	Slash predicted using our method (BDT)	Slash predicted using general Montana factor (BDT)
2013	12,946	12,894
2014	13,059	12,894
2015	12,957	12,894
2016	13,029	12,895
2017	13,075	12,894
2018	13,099	12,895
2019	13,068	12,894
2020	12,242	11,957
2021	13,108	12,895
2022	14,628	12,894

[17] Morgan, T. An Assessment of Forest-based Woody Biomass Supply and Use in Montana. Report for Montana Department of Natural Resources and Conservation. Missoula (MT): 2009.

Table 4.1.7. Timber harvest and recoverable slash volumes by harvest area

Year	Harvest Area	Harvested Area (Acres)	Harvest (MMBF)	Recovered Slash (BDT)	Distance to Pablo (mi)	Landings (#)	Delivered Cost ($/BDT)
2013	Hellroaring	4,362	8.7	6,247	14	167	14
	Jette	3,267	4.9	3,534	20	118	14
	Rattle Snake	1,095	2.0	1,454	31	52	17
	Sullivan	2,325	2.4	1,711	35	70	19
2014	Deep Draw	2,776	7.6	5,480	30	134	19
	Dry Fork	942	0.7	532	52	23	25
	North Buffer Zone	2,806	8.8	6,348	7	86	11
	Stevens	1,030	1.0	700	42	73	40
2015	Ferry Basin	4,718	7.2	5,201	30	125	19
	Skunk	2,343	4.3	3,059	40	187	26
	Yellow Bay	3,371	6.6	4,697	29	94	17
2016	Central Buffer Zone	2,281	6.3	4,510	17	69	14
	Delaware	2,090	3.8	2,745	36	90	25
	Eva Paul	1,116	1.4	1,024	38	42	20
	Revais	3,518	6.0	4,330	40	91	21
	Sheep Springs	453	0.6	421	35	11	22
2017	Irvine	2,565	3.1	2,256	28	126	20
	Moss Peak	2,898	8.6	6,207	13	129	13
	Pistol Creek	3,360	6.4	4,612	38	187	20
2018	Lamoose	1,541	2.4	1,713	33	41	20
	South Buffer Zone	1,653	4.8	3,491	27	99	20
	Sunny Slope	3,007	7.3	5,281	17	154	16
	Welcome Springs	1,635	3.6	2,613	44	26	21
2019	Boulder	5,211	10.7	7,618	23	167	16
	Meadow	2,889	5.6	4,097	31	128	22
	Saddle Mountain	1,382	1.8	1,353	39	69	23
2020	Charity Peak	5,982	12.7	9,317	43	214	23
	Schley	1,844	4.0	2,925	42	63	22
2021	Dog Lake	1,487	2.2	1,547	49	31	23
	Magpie	4,683	10.0	7,330	42	99	21
	Yellow Bay	3,371	5.9	4,231	29	94	18
2022	Seepay-Vanderburg	9,318	18.1	14,628	44	237	24

FVS Settings

All simulations were run using FVS Version 0979 – Inland Empire Expanded variant. The starting year for each simulation is 1999 and the simulation end year is one year past treatment year. For example, for a treatment in 2014, the simulation would begin in 1999 and end in 2015.

Input Database – CSKT_Database

Total of 296 CFI Plots - 1/5th acre plots
- Seral Cluster “A” Plots – 140
- Seral Cluster “B” Plots - 23
- Seral Cluster “C” Plots - 46
- Seral Cluster “D” Plots - 7
- Seral Cluster “E” Plots - 29
- Seral Cluster “F” Plots - 57
- Seral Cluster “G” Plots - 27
- Seral Cluster “H” Plots - 16
- Seral Cluster “I” Plots - 1
- Seral Cluster “J” Plots - 37
- Seral Cluster “K” Plots - 8
- Seral Cluster “L” Plots – 5

Volume Settings

Defect – Cubic Foot – for all species:
- 5 inch trees = 0.05;
- 10 inch trees = 0.05;
- 15 inch trees = 0.07
- 20 inch trees = 0.07;
- 25 inch trees = 0.10;
- 30 inch trees = 0.11
- 35 inch trees = 0.12;
- 40 inch and larger trees = 0.13

Defect – Board Foot – for all species:
- 5 inch trees = 0.05;
- 10 inch trees = 0.05;
- 15 inch trees = 0.07
- 20 inch trees = 0.07;
- 25 inch trees = 0.10;
- 30 inch trees = 0.11
- 35 inch trees = 0.12;
- 40 inch and larger trees = 0.13

Board foot Volume Settings;
- ALL SPECIES (CODE = 0);
- MINIMUM DBH = 7.00;
- TOP DIAMETER = 4.00;
- STUMP HEIGHT = 1.00
- FORM CLASS = 80.00;
- METH OF VOL CALC = 6.

Prescription Settings

Prescriptions were applied based upon the Seral Cluster (forest type) and Fire-regime as described in Table 4.1.1. Below are the general settings for each of the prescriptions.

Clearcut (CC)
- Reserve 5 TPA > 21”
- Applied to Seral Clusters D, E, G, H, J, K, L

PCT
- Low thin – thin to 300 trees per acre
- Applied to Seral Clusters B, C, D

Seed tree
- Residual of 10 TPA
- Applied to Seral Clusters F, G, H

Un-even aged (UA)
- Q quotient of 1.1 for all un-even aged scenarios
- Thinned to residual BA of 45, 60, 70. Depends on Seral Cluster
- Applied to Seral Clusters F, G, J, K

Commercial Thin (Thin)
- Applied to Seral Cluster J, K
- Thin from below to specified BA (70, 80). Depends on Seral Cluster

Shelterwood (SW)
- Residual of 30 TPA
- Applied to Seral Clusters G