BGP & SOCIAL ASSETS

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BGP	biogeophysical
BDMt	bone dry metric tons
CAAM	Community Asset Assessment Model
CCF	Community Capitals Framework
EPP	Environmentally Preferred Products
GIS	Geographic Information System
MCDA	multi-criteria decision analysis
PNW	Pacific Northwest

EXECUTIVE SUMMARY

The Environmentally Products Team (EPP) was tasked with developing an integrated, multifaceted approach to a socio-market perspective of biorefinery value chain outputs. As part of this process, the EPP team developed a holistic approach to biorefinery supply chain analysis in terms of combining biogeophysical (BGP) assets with difficult to operationalize social assets to identify communities in the NARA region more likely to support aviation biofuel facilities. The EPP team worked over the course of the project to develop, operationalize, and refine a social asset model, the Community Asset Assessment Model (CAAM), that provides the first nationally available quantitative measures of three key social assets, social capital, cultural capital, and human capital. The CAAM model, which analyzes social constraints, was combined with biogeophysical (BGP) GIS analysis, which measures physical restraints, in a step-wise process to assess the potential of retrofitting pulp mills into a biorefinery. The assessment was performed in the NARA region and resulted in identifying one pulp mill that has strong BGP and social characteristics, indicating the community has a greater likelihood of supporting biofuel facilities, Georgia-Pacific Wauna Mill in Clatsop County Oregon. Our methodology to combine BGP analysis and social asset analysis via the CAAM model provides the most complete site-selection model developed and utilized to date, providing invaluable insight into physical and social constraints to biorefinery site selection.

INTRODUCTION

In order to examine social and physical constraints to supporting a biorefinery in the NARA region, the BGP and Social Assets research group developed and refined both biogeophysical and social measures. BGP measures were refined to examine specific facilities: pulp mills in the NARA region that could be retrofitted for a biorefinery as an additional cost-saving measure. Measures of annual biomass availability, electricity and natural gas rates, and infrastructure were weighted and combined to rank facilities by their biogeophysical assets. Our model of social assets, the CAAM model, was refined to include additional key indicators of the three social assets, including adding Non-Rent Seeking Groups and Non-Profit Organization to the social capital measure, number of Arts related organizations and businesses to the cultural capital measure, and percentage of the population that is obese and percentage of population with low birth-weights to the human capital measures. The refined assets were combined using a step-wise process: (1) ranking of facilities based on BGP GIS analysis, and (2) examining CAAM measures to identify the ranked facilities with sufficient levels of social assets to support a biorefinery.

Task 1: BGP and Social Assets

Task Objective

The objective was to identify opportunities and barriers for a regional approach to aviation biofuels through community assessment of key capitals (biogeophysical and social) that are found to impact success of similar projects. The inquiry included developing quantitative measures for core social assets (the Community Asset and Attribute Model, CAAM) often excluded from site-selection modeling due to limited availability and lack of understanding, and combining with physical asset analysis through GIS application in a step-wise process to identify communities that are more likely to support aviation biofuel facilities.

Methodology and Results

The Community Capitals Framework (CCF) is the basis for measuring community capacity to assess community assets through seven capitals that combine distinct resources. The methodology utilized a step-wise process that combines biogeophysical analysis of natural, financial and built capitals with social asset analysis of social capital, cultural capital and human capital to identify communities with the level of resources needed to support aviation biofuel facilities. The results presented in this report represent the penultimate iteration of the model, refined and validated over the entire NARA project.

Process Step 1: Biogeophysical Assessment

The first step involved conducting a biogeophysical assessment of pulp mills in the NARA region to assess their repurpose potential as an aviation biofuel refinery. In contrast to initial modeling, the biogeophysical analysis was refined to focus on facilities that could be retrofitted for a biorefinery and included more precise measurements of several biogeophysical measures (Table BGP-1.1). The modeling focused on retrofitting active pulp mills rather than building new facilities as a cost saving measure to aid economic success.

Table BGP-1.1. Biogeophysical Model Refinement

Community Assets	Beginning of NARA: Initial Model	End of NARA: Refined Model
Natural, Financial & Built Capital	Cities selected by: Population greater than 1,000; located within 1.6 km of major road and rail; near large quantities of biomass; and, near petroleum terminals.	Pulp mills assessed based on: annual biomass availability; labor wages; electricity and natural gas rate; and infrastructure compatibility with a conversion process.

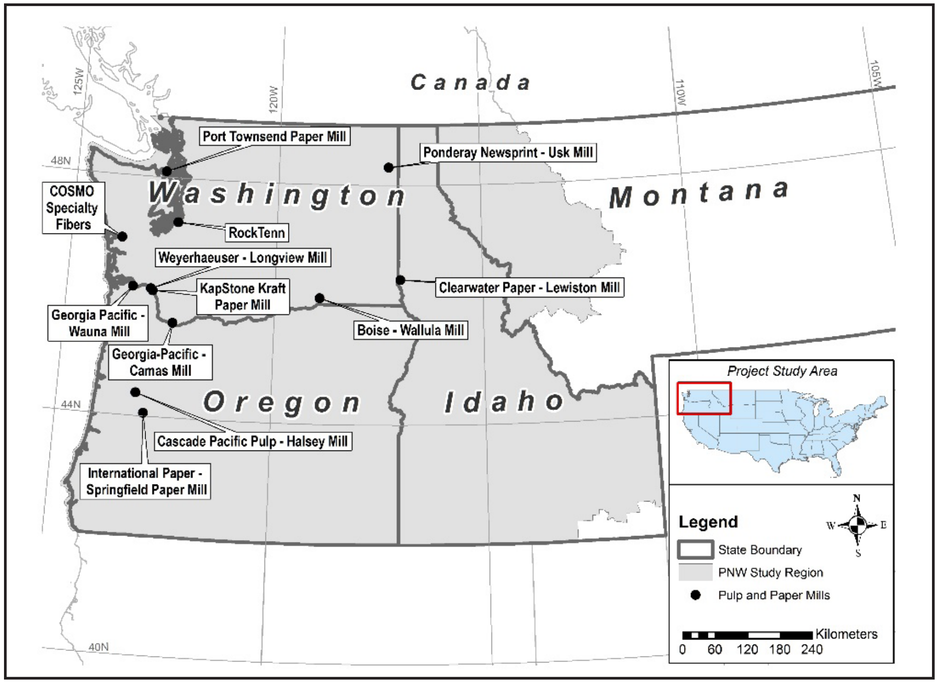

Figure BGP-1.1. Pulp Mills in PNW Study Region (n=12)

Active pulp mills in the region were assessed using a biorefinery scenario: "annual feedstock demand of 757,500 bone dry metric tons (BDMt) of forest residuals to the refinery gate, uses mild bisulfite pretreatment to convert wood into pulp, produces approximately 132.5 million liters of biojet fuel per year, and requires at least 60.7 hectares for plant infrastructure" (Martinkus et al., submitted; Figure BGP-1.1). A facility siting decision matrix was constructed, combining multi-criteria decision analysis (MCDA) with GIS, to rank active pulp mills based on biomass availability, electricity and natural gas rates, infrastructure compatibility with a biorefinery, and average labor wage (Table BGP-1.2). Facility assets were scored using a scale from 1 to 5 for each siting criterion (5 = best match), and weighted according to percentage of cost relative to the total cost of building/operating greenfield biorefinery.

Table BGP-1.2. Biogeophysical Facility Siting Decision Matrix

	Wtd. Avg. Delivered Feedstock Cost ($/BDMt)	Electricity ($/kWh)	Natural Gas ($/k.c.m.)	Infrastructure: % reduction from Greenfield Cost	Avg. Wage ($/week)
Scale					
5	65.8	0.047	0.252	41%	571
4	74.4	0.051	0.268	37%	627
3	82.9	0.055	0.284	33%	683
2	91.4	0.060	0.300	30%	739
1	99.9	0.064	0.316	26%	795
weights	7.0	2.3	1.1	7.5	2.1

Table BGP-1.3. CAAM Refinement

Community Assets	Beginning of NARA: Initial Model	End of NARA: Refined Model
Social Capital Rupasingha et al, 2006 2009 data used	# Rent-Seeking Groups: political, labor, professional and business organizations	# Rent-Seeking Groups: political, labor, professional and business organizations # Non-Rent Seeking Groups: civic organizations, bowling centers, golf clubs, fitness centers, sports organizations and religious organizations # Non-Profit Organizations % Voter Turnout
Cultural Capital WESTAF	$ Average annual revenues of arts-related goods and services based on all revenues between 2002 and 2010	# Arts related organizations # Arts related business # Occupational employment in the arts $ Revenues of arts related goods and services
Human Capital County Health Ranks	% Self-reports of poor health condition (physically and mentally)	Health: % Low birth-weight % Premature deaths % Obese (BMI >30) % Self-reports of poor health condition (physically and mentally)
All counts (#) and amounts ($) are calculated as a rate of the population per 10,000		

Process Step 2: Social Asset Analysis

Following the ranking of active pulp mills based on biogeophysical assessment, social asset analysis of facilities was conducted utilizing ranked scores for assets that have been found to impact development and implementation of highly technical infrastructure projects. Quantitative county-level measures of social capital, cultural capital, and human capital were applied to facilities identified in Process Step 1. These quantitative measures were developed by combining 7 national datasets with a total of 25 data points for each county in the United States to examine com-

Table BGP-1.4. Comparison of Average Scores by Region Definition

Asset	National	West	Pacific Northwest (PNW)
	N = 3,108	*N = 413*	*N = 128*
Social Capital			
Avg. Score (2009)	**-0.0043**	**0.0413**	**0.0820**
Minimum score	-4.29	-3.06	-2.51
Maximum score	23.08	7.88	3.52
Missing counties	40	35	0
Creative Capital			
CVI score (2010)	**0.491**	**0.686**	**0.5734**
Human Capital			
Avg. Health (2013)	**0.0838**	**-1.4247**	**-1.5927**
Minimum score	-7.66	-7.66	-6.11
Maximum score	12.50	6.21	2.71
Missing counties	632	82	15
Note: missing values are mostly all counties in Alaska and Hawaii, plus seven counties in Georgia			

Table BGP-1.5. Combined Biogeophysical and Social Asset Scores

Rank	Site name	Facility Score	County and State	Social Capital	Creative Capital	Human Capital Health
1	Cosmo Specialty Fibers	94.6	Grays Harbor County, WA	-0.30 (-0.03)	0.308 (-0.602)	1.49 (1.72)
2	Weyerhaeuser - Longview Mill	88.3	Cowlitz County, WA	-0.66 (-0.59)	0.331 (-0.550)	1.67 (1.82)
3	SP Fiber Technologies	87.2	Yamhill County, OR	-0.68 (-0.61)	0.510 (-0.144)	-2.88 (-0.72)
4	Georgia-Pacific – Wauna Mill	87.0	Clatsop County, OR	0.64 (0.45)	0.985 (0.934)	-2.61 (-0.57)
5	Georgia-Pacific – Camas Mill	81.8	Clark County, WA	-1.29 (-1.09)	0.600 (0.060)	-2.40 (-0.45)
6	KapStone Kraft Paper Mill	80.8	Cowlitz County, WA	-0.66 (-0.59)	0.331 (-0.550)	1.67 (1.82)
7	International Paper - Springfield Mill	80.3	Lane County, OR	-0.15 (-0.19)	0.961 (0.879)	-1.62 (-0.01)
8	Cascade Pacific Pulp Halsey Mill	78.0	Linn County, OR	-0.46 (-0.43)	0.300 (-0.620)	-0.71 (0.49)
9	Georgia-Pacific – Toledo Mill	77.5	Lincoln County, OR	0.29 (0.16)	0.901 (0.743)	-0.58 (0.56)
10	RockTenn	72.8	Pierce County, WA	-1.10 (-0.94)	0.655 (0.185)	-0.91 (0.38)
11	Clearwater Paper Lewiston Mill	65.0	Nez Perce County, ID	-0.08 (-0.13)	0.526 (-0.107)	-0.79 (0.45)
12	Boise Wallula Mill	52.4	Walla Walla County, WA	-0.56 (-0.51)	0.690 (0.265)	-2.25 (-0.37)
13	Frenchtown Kraft Mill	26.3	Missoula County, MT	0.11 (0.03)	0.262 (-0.706)	-0.10 (0.84)

munity suitability in site-selection. The CAAM Model developed at the beginning of NARA has been considerably refined to include more indicators of each of these three important capitals, providing a more robust assessment of the availability and level of each asset (Table BGP-1.3).

From these combined datasets, capital scores were created by creating one scale score for each asset adding all relevant indicators (Table BGP-1.4). Minimum cut-off scores were developed based on regional mean scores for each asset to identify facilities with social assets greater than the regional average. Communities exceeding the benchmarks outperform the region and are considered likely candidates for site-selection based on social asset measures. Regional cut-offs were validated through subsequent case study analysis of similar projects to determine their predictive capacity for project implementation success.

Once social assets measures are combined with biogeophysical measures, one facility can be identified as having the highest potential for successful development of a retrofitted biorefinery: Georgia-Pacific Wauna Mill (Table BGP-1.5).

Conclusion

The NARA EPP team, using the Community Capitals Framework as an organizing structure, developed unique capacities for biorefinery siting as their contribution to this project. The Biogeophysical mapping component provided necessary information on infrastructure, feedstock and logistics, and the CAAM model provides a one-of-a-kind resource for assessing social, cultural and human capital at the county level. When combine in a step-wise process, these two tools supported mapping of which provided meaningful input to inform the implementation decisions of the project, including the selection of mill sites for repurpose into a biorefinery. In addition to these focused, “tactical” applications for the biogeophysical and CAAM social components, which improved the project implementation, the long-term outputs for these project efforts will be available for future use by other projects. The CAAM in particular will stand as a national resource providing easy access to community information with applications far beyond the NARA project.

NARA OUTPUTS

PUBLICATIONS

Martinkus, N., A. Kulkarni, N. Lovrich, P. Smith, W. Shi, J. Pierce, M. Wolcott, and S. Brown. 2012. An Innovative Approach to Identify Regional Bioenergy Infrastructure Sites. In Proceedings of the 55th International Convention of Society of Wood Science and Technology, August 27-31 in Beijing, CHINA. Ch. 3, Energy and Carbon (EC-3), 11pp. *http://www.swst.org/meetings/AM12/pdfs/papers/EC-3.pdf*

Lovrich, N., W. Shi, N. Martinkus, P. Smith, J. Pierce, A. Kulkarni, M. Gaffney, M. Wolcottc, and S. Brown. 2012. Integrating Social Capital in Biojet Feedstock Facility Siting Decisions. In Proceedings of the Sun Grant Initiative 2012 National Conference: Science for Biomass Feedstock Production and Utilization, Oct. 2-5, 2012. New Orleans, LA, USA. Ch. 4, Modeling and Metrics. 8pp. *http://sungrant.tennessee.edu/NR/rdonlyres/8CF2F183-8B72-4E48-9E2F-BCAB4E421C7A/3626/42Lovrich_Nicholas.pdf*.

Martinkus, N., W. Shi, N. Lovrich, J. Pierce, P. Smith, and M. Wolcott. 2014. Integrating Biogeophysical and Social Assets into Biomass-to-Biofuels Supply Chain Siting Decisions. *Biomass & Bioenergy* 66:410-418.

Rijkhoff, S., S. Hoard, M. Gaffney and P. Smith. 2016. *Communities Ready for Takeoff: Integrating Social Assets for Bio-fuel Site-selection Modeling*. Revise and Resubmit from Renewable Energy (RENE-D-15-017240).

Martinkus, N., Rijkhoff, S., Hoard, S., Shi, W., Smith, P., Gaffney, M., and Wolcott, M. 2016. Biorefinery Site Selection Using a Stepwise Biogeophysical and Social Analysis Approach. Submitted to *Biomass and Bioenergy*. In review.

Martinkus, N., and Wolcott, M. 2016. A Multi-Criteria Decision Support Tool for Biorefinery Siting. *To be submitted to Biofuels, Bioproducts, and Biorefining*.

PRESENTATIONS

Smith, P.M., N.A. Martinkus, A. Kulkarni, N. Lovrich, W. Shi, J. Pierce, M. Wolcott, and S. Brown. 2012. An Innovative Approach to Identify Regional Bioenergy Infrastructure Sites. Presented at the Western Montana Corridor NARA Community Roadmap Development Meeting. June 13, 2012. University of Montana, Missoula, MT.

Smith, P., Lovrich, N., W. Shi, N. Martinkus, J. Pierce, A. Kulkarni, M. Gaffney, and M. Wolcott. 2012. Physical and Social/Community Asset Mapping in the NARA Region. Presentation at the NARA Annual Meeting, Sept. 14 in Missoula, MT.

Smith, P.M., N.A. Martinkus, A. Kulkarni, N. Lovrich, P.M. Smith, W. Shi, J. Pierce, M. Wolcott, and S. Brown. 2012. An Innovative Approach to Identify Regional Bioenergy Infrastructure Sites. Presentation at the 55th Annual Convention of the Society of Wood Science and Technology. August 27-31 in Beijing, CHINA.

Nicholas Lovrich, N., W. Shi, N. Martinkus, P. Smith, J. Pierce, A. Kulkarni, M. Gaffney, M. Wolcott, and S. Brown. 2012. Integrating Social Capital Into Biojet Feedstock Facility Siting Decisions. *Presened at the Sun Grant Initiative 2012 National Conference*: Science for Biomass Feedstock Production and Utilization, Oct. 2-5 in New Orleans, LA, USA.

Smith, P.M., W. Shi, N. Martinkus, N. Lovrich, J. Pierce, M. Wolcott, and M. Gaffney. 2013. An Integrated and Multidimensional Approach to Biomass-to-Biofuel Supply Chain Siting in the WMC. *Presentation at the Year 2, NARA Annual Meeting*, Corvallis, OR. Sept. 11.

Shi, W., P. Smith, N. Martinkus, N. Lovrich, J. Pierce, M. Wolcott, and M. Gaffney. 2013. Integrating Biogeophysical and Social Assets Into Biomass-to-Biofuels Supply Chain Siting Decisions. *Poster presentation at the Year 2, NARA Annual Meeting*, Corvallis, OR. Sept. 10.

Martinkus N. 2014. Assessing Existing Plant Assets for Biorefinery Siting. Presentation at the NARA Annual Meeting. Sept. 15-17 in Seattle, WA.

Rijkhoff, S., S. Hoard, M. Gaffney, P. Smith, N. Martinkus, N. Lovrich, J. Pierce and M. Wolcott. 2014. Community Asset Assessment Modeling for Informed Biofuel Location Decision-Making. Paper presentation at the TAPPI International Bioenergy & Bioproducts Conf., Sept 17-19, Seattle, WA.

Rijkhoff, S., S. Hoard, M. Gaffney, P. Smith, N. Martinkus, N. Lovrich, J. Pierce and M. Wolcott. 2014. Community Asset and Attribute Modeling: Applying Social Data to Inform Bio-Fuel Site Selection. Presentation at the Pacific NW Political Science Association Annual Meeting, Oct 9-11 in Bend, OR.

Smith, P.M. 2014. Social Assets Assessment and Biorefinery value chain outputs. Presentation at the FAA ASCENT Advisory Board Meeting, Oct. 16-17, Alexandria, VA.

Hoard, S., Gaffney, M., & Mueller, D. 2015. *Community Asset & Attribute Modeling*, NARA Annual Meeting, September, Spokane, WA.

Gaffney, M., P. Smith, S. Rijkhoff and S. Hoard. Social Asset Decision Tools for Successful Biorefinery Siting. 2015. Presentation at the FAA ASCENT Annual Meeting. Mar. 10-12. Alexandria, VA.

Smith, P.M., W. Shi, M. Gaffney, S. Hoard, I. Ibarolla, B. Miller, and G. Johnston. 2015. Aviation Fuel Supply Chain Stakeholder

Gaffney, M. P. Smith, S. Rijkhoff and S. Hoard. 2015. Community Asset and Attribute Model. Presentation at the USDA NARA project's 4th year annual meeting. Sept. 15-17. Spokane, WA.

Smith, P.M., M. Gaffney, N. Martinkus, M. Wolcott, S. Rijkhoff, S. Hoard, W. Shi, P. Venugopal, N. Lovrich and J. Pierce. 2015. Stakeholders Assessment and Biorefinery Value Chain Outputs. Presented at the FAA ASCENT Biannual Advisory Board Meeting at Boeing Museum of Flight, Oct. 13-15, Seattle, WA.

Martinkus, N., Rijkhoff, S., Hoard, S., Shi, W., Smith, P., & Gaffney, M. 2016. *A stepwise biogeophysical and social analysis to approach site selection of biorefineries*. Northwest Wood Based Biofuels Coproducts Conference, April, Seattle, WA

POSTERS

Nicholas Lovrich, N., W. Shi, N. Martinkus, P. Smith, J. Pierce, A. Kulkarni, M. Gaffney, M. Wolcott, and S. Brown. 2012. Physical and Social Assets Mapping in the NARA Region. Poster presentation at the NARA Annual Meeting, Sept. 14 in Missoula, MT.

Shi, W., P. Smith, N. Martinkus, N. Lovrich, J. Pierce, M. Wolcott, and M. Gaffney. 2013. Integrating Biogeophysical and Social Assets Into Biomass-to-Biofuels Supply Chain Siting Decisions. Poster presentation at the Year 2, NARA Annual Meeting, Corvallis, OR. Sept. 10.

Shi, W., P. Smith, N. Martinkus, N. Lovrich, J. Pierce, M. Wolcott, and M. Gaffney. 2013. Integrating Biogeophysical and Social Assets Into Biomass-to-Biofuel Supply Chain Siting Decisions. Poster presentation at the 56th International Convention of the Society of Wood Science & Technology, June 9, Austin, TX.

Rijkhoff, S., S. Hoard, M. Gaffney, P. Smith, N. Martinkus, N. Lovrich, J. Pierce and M. Wolcott. 2014. Refining Community Asset and Attribute Modeling: Applying Social Data to Inform Bio-Fuel Project Site Selection in the NARA Region. Poster presentation at the NARA Annual Meeting, Sept 15-17 in Seattle, WA.

Martinkus, N., Rijkhoff, S., Shi, W., Venugopal, P., Hoard, S., Gaffney, M., Smith, P., & Mueller, D. 2015. Refining community asset and attribute modeling: Applying social data to inform bio-fuel project site selection in the NARA region [poster], Academic Showcase, March, Pullman, WA.

Rijkhoff, S., S. Hoard, M. Gaffney, P. Smith, N. Martinkus, N. Lovrich, J. Pierce and M. Wolcott. 2014. Refining Community Asset and Attribute Modeling: Applying Social Data to Inform Bio-Fuel Project Site Selection in the NARA Region. Poster presentation at the NARA Annual Meeting, Sept 15-17 in Seattle, WA.

Hoard, S., Gaffney, M., & Mueller, D. 2015. *Community Asset & Attribute Modeling*, NARA Annual Meeting, September, Spokane, WA.

Martinkus, N., S. Rijkhoff, W. Shi, P. Venugopal, S. Hoard, M. Gaffney, P. Smith, and D. Mueller. 2015. Refining Community Asset and Attribute Modeling: Applying Social Data to Inform Biofuel Project Site Selection in the NARA Region. Poster presentation at the USDA NARA project's 4th year annual meeting. Sept. 15-17. Spokane, WA.

NARA OUTCOMES

The development of facility siting criteria and weights have evolved over the five-year project. Initially, biogeophysical siting measures were applied to cities with the assumption that a suitable greenfield biorefinery location could be found within the selected city. Cities were identified using a GIS-based Weighted Overlay Analysis. The next iteration used a mixture of qualitative and quantitative measures in a decision matrix as siting criteria, applied to existing facilities for site selection. Weights were derived from cost components in a biorefinery Techno-Economic Analysis (TEA). Finally, a transparent and replicable method for selecting facility siting criteria and weights was developed based on the major capital and operational cost components identified in a biorefinery TEA. Only costs that vary geospatially were selected as siting criteria. Criteria weights were developed by determining the percentage cost of each criteria relative to all other criteria. Using geospatial cost components as siting criteria allows for the ranking and ultimate identification of facilities that can procure and process feedstock at the least cost in a defined region.

The social asset modeling in combination with biogeophysical assessment has provided valuable insight into communities within the Pacific Northwest with the highest potential to successfully support the development and implementation of a biorefinery. Over the five-year period, social asset assessments have been considerably refined and validated to enhance predictive capacity. The development of the Community Asset and Attribute Model which developed quantitative measures of three key social assets, social, cultural and human capitals, are the first nationally-available quantitative measurements of these important assets that are often unavailable for site-selection modeling.

FUTURE DEVELOPMENT

The biogeophysical facility siting decision matrix was developed as a generic model that may be applied to any feedstock and any biofuel conversion process. The use of existing facilities as repurposed or co-located biorefineries may provide significant cost savings for cellulosic or advanced biorefineries trying to reach or maintain commercial status. The decision matrix was expanded to include environmental metrics along with the economic and social metrics identified in this report for use in facility siting. Future work will assess existing biomass processing facilities, such as sawmills, for their use as a co-located depot in a biorefinery-and-depot supply chain. Validation of the selected siting criteria and weights will be performed when existing facilities are repurposed into a biorefineries and data is available for comparison to the estimated values developed for this work. Additional work may include converting the economic, environmental, and social decision matrix siting model to a geographic user interface for use in a web browser. Stakeholders and investors could play out policy or business scenarios to determine the best facility for repurpose within a defined region.

The CAAM model is in the final stages of validation and refinement. Refinement includes adding measures of political capital based on additional nationally-available datasets. Upon completion of the final validation and refinement, the CAAM model will be made available for those who wish to incorporate these assets in site-selection.

LIST OF REFERENCES

Emery, M. & Flora, C. (2006). Spiraling Up: Mapping Community Transformation with the Community Capitals Framework. Journal of Community Development Society, 37, 19-35. Retrieved from https://www.uvm.edu/rsenr/rm230/costarica/Emery-Flora-2006.pdf

Martinkus, N., Shi, W., Lovrich, N., Pierce, J., Smith, P. & Wolcott, M. (2014). Integrating Biogeophysical and Social Assets Into Biomass-to-Biofuels Supply Chain Siting Decisions. Biomass & Bioenergy, 66, 410-418. doi.org/10.1016/j.biombioe.2014.04.014

Martinkus, N., Rijkhoff, S., Hoard, S., Shi, W., Smith, P., Gaffney, M., & Wolcott, M. (2016). Biorefinery Site Selection Using a Stepwise Biogeophysical and Social Analysis Approach. Submitted to Biomass and Bioenergy. In review.

Rijkhoff, S., Hoard, S., Gaffney, M. & Smith, P. (2016). Communities Ready for Takeoff: Integrating Social Assets for Bio-fuel Site-selection Modeling. Revise and Resubmit from Renewable Energy (RENE-D-15-017240).