Aim 4 – Economics & Policy
PINEMAP Year 2 Final Progress Report
March 2013

This is the final Aim progress report for year 2 (March 2012-February 2013). Please update the outputs list and provide brief progress updates on milestones and work plan tasks as applicable. The information provided in these reports is used to track Aim-level outputs and outcomes over the course of the project and to fulfill NIFA reporting requirements via the annual continuation proposals and CRIS progress report.

Please return the updated report to Jessica Ireland no later than **March 22**.

Outputs

List ***Products*** developed/completed January 2012-current (including published, in press, or in review peer-reviewed publications; other written materials such as white papers, research summaries, fact sheets, or popular press articles; audio or video products; etc.).

A list of documented Aim 4 year 2 publications is provided below; please update as necessary and highlight in yellow any publications added to the list in the March 2013 Progress Report.

Peer-reviewed Publications (January 2012-current)

Abt, K.L., R. Abt, and C. Galik. 2012. Effect of bioenergy demands and supply response on markets, carbon and land use. *Forest Science* 58(5): 523-539. doi: http://dx.doi.org/10.5849/forsci.11-055

Abt, R.C. and K.L. Abt. 2012. Potential impace of bioenergy demand on the sustainability of the southern forest resource. Journal of Sustainable Forestry 32(1-2): 175-194.

Chudy, R., R.C. Abt, R. Jonsson, J.P. Prestemon, F.W. Cubbage. In press. Modeling the impacts of EU bioenergy demand on the forest sector of the Southeastern U.S. International Journal of Energy and Power Engineering

Dwivedi P, Bailis, R (2013) Is use of pulpwood and logging residues for bioenergy development a viable carbon mitigation strategy? Global Change Biology Bioenergy (in review)

Dwivedi P, Gan J, Bailis R, Khanna M (2013) Declining forestland holding sizes could reduce carbon benefits of electricity generated from forest biomass. Global Change Biology Bioenergy (in review)

Dwivedi P, Gan J (2013) How changing climate affects southern pine beetle outbreaks in US South? (in preparation)

Dwivedi, P., J. Gan, R. Bailis, M. Khanna. 2012. Large capacity forest biomass power plants may or may not reduce greenhouse gas emissions. *Environmental Science & Technology*, in review.

Galik, C.S. and R.C. Abt. 2012. The effect of assessment scale and metric selection on the greenhouse gas benefits of woody biomass. *Biomass and Bioenergy* 44: 1-7.

Gan, J., C.T. Smith, and J.W.A. Langeveld. 2012. Effects of considering greenhouse gas consequences on fertilizer use in loblolly pine plantations. *Journal of Environmental Management* 113:383-389. http://dx.doi.org/10.1016/j.jenvman.2012.09.015

Gan, J. 2013. Economic and environmental competitiveness of US-made forest products: Implications for offshore outsourcing. *Journal of Forestry* 111(2): 94-100.

Gruchy, S.R., D.L. Grebner, I.A. Munn, O. Joshi, and A. Hussain. 2012. An assessment of nonindustrial private forest landowner willingness to harvest woody biomass in support of bioenergy production in Mississippi: A contingent rating approach. *Forest Policy and Economics* 15: 140-145. doi: http://dx.doi.org/10.1016/j.forpol.2011.09.007

Henderson, J., I.A. Munn, D.L. Grebner, and S. Roberts. A comparison of loblolly pine growth and yield models. *Southern Journal of Applied Forestry*, accepted.

Joshi, O., D.L. Grebner, A. Hussain, and S.C. Grado. Landowner knowledge and willingness to supply woody biomass for wood-based bioenergy: Sample selection approach. *Journal of Forest Economics*, in press.

Joshi, O., D.L. Grebner, I.A. Munn, and A. Hussain. Determinants of forest landowners' choice for preferred harvesting methods to supplying woody biomass in Mississippi. *Forest Science*, in press.

Joshi, O., Grebner, D.L., Henderson, J.E., Grado, S.C., and I.A. Munn. Economic impacts of woody biomass utilization for bioenergy in Mississippi. *Forest Products Journal*, in review.

Kreye, M.M., D.C. Adams, and F.J. Escobedo. The value of forest conservation for water quality protection. *Forest Policy and Economics*, in review.

Nepal, P., Grala, R.K., and D.L. Grebner. 2012. Financial feasibility of increasing carbon sequestration in harvested wood products in Mississippi. *Forest Policy and Economics* 14(1): 99-106. doi: http://dx.doi.org/10.1016/j.forpol.2011.08.005

Nepal, P., R.K. Grala, and D.L. Grebner. 2012. Financial implications of enrolling to Mississippi forest landowners in carbon offset programs. *Southern Journal of Applied Forestry* 36(1): 5-10. doi: http://dx.doi.org/10.5849/sjaf.09-067

Nepal, P., R.K. Grala, D.L. Grebner, and R. Abt. Impact of harvest-level changes on carbon accumulation and timber stumpage prices in Mississippi. *Southern Journal of Applied Forestry*, in press.

Perez-Verdin, G., J.J. Navar-Chaidez, D.L. Grebner, and C. Soto Alvarez. 2012. Availability and production costs of forest biomass as a feedstock for bioethanol production. *Forest Systems* 21(3): 526-537. doi: http://dx.doi.org/10.5424/fs/2012213-02636

Susaeta, A.I., D.R. Carter, S.J. Change, and D.C. Adams. The impact of hurricane risk on optimal forest management in southern U.S. pine plantations: Application of a generalized Reed model. *Canadian Journal of Forest Research*, in review.

Susaeta, A.I., D.R. Carter, and S.J. Change. Economics of carbon sequestration under fluctuating economic environment, forest management and technological changes: an application to forest stands in the southern United States. *Journal of Forest Economics*, in review.

Susaeta, A.I., C.A. Gonzalez-Benecke, D.R. Carter, T.A. Martin, and E.J. Jokela. 2012. Economical sustainability of pinestraw raking in slash pine stands in the southeastern United States. 2012. *Ecological Economics* 80: 89-100. doi: http://dx.doi.org/10.1016/j.ecolecon.2012.05.010

Timilsina, N., W. Cropper, Jr., F. Escobedo, and J. Tucker. Predicting understory species richness from stand and management characteristics using regression trees. Forests 4(1): 122-136 doi: 10.3390/f4010122

Timilsina, N., F. Escobedo, W. Cropper, Jr., T. Brandeis, S. Delphin, and S. Lambert. A framework for identifying carbon hotspots and forest management drivers. *Journal of Environmental Management* 114: 293-302. http://dx.doi.org/10.1016/j.jenvman.2012.10.020

Events/Activities (January 2012-current)

→ Provide a bulleted list of presentations (oral and poster) given at meetings or conferences. The format for citing presentations is as follows: Presenter(s)/Author(s). Date. Name/title of meeting/conference, location. *Indicate poster presentations by placing [poster] at end of citation. *Highlight in yellow presentations added to the list in the March 2013 Progress Report.*

Abt, K.L. and R.C. Abt. "Timber supply: too much or too little?" Departmental Seminar, Department of Forestry, College of Natural Resources, NCSU, April 23, 2012.

Abt, R.C. and K.L. Abt. "Forest Markets, Spatial Scale, and Carbon Accounting." CENREP Seminar, Center for Environmental Resource Economic Policy, NCSU, April 27, 2012.

Abt, R.C. "Bioenergy Demand and the Southern Forest Resource". Soil and Mulch Producers Council. Atlanta, GA. October 2012.

Abt, R.C. and C. S. Galik. "Southeastern U.S. Forest Bio-Economic Dynamics: The Impact of Spatial and Temporal Scale on Carbon Accounting". Nicholas Institute for Environmental Policy Solutions & UPEP Environmental Institutions Seminar Series. September 21, 2012.

Abt, R.C. and C. S. Galik. "Southeastern U.S. Forest Bio-Economic Dynamics: The Impact of Spatial and Temporal Scale on Carbon Accounting". ERPI Research Meeting Webinar. November 15, 2012.

Abt, K.L. R.C. Abt, R. Sheffield and M. Lupold. "Timber Famine Meets Wall of Wood". SOFEW Annual Meeting. Charlotte, NC. March 2012.

Abt, R.C. and K. L. Abt. "The carbon impact of increased loblolly pine growth: potential market and land use feedback" Pinemap Aim 4 Webinar. December 12, 2012.

Adams, D.C., “Integrating Biophysical and Economic Values of Wetlands: Recent Advances in Ecosystem Service Valuation.” 9th INTECOL International Wetlands Conference, Orlando, FL (USA), June 4, 2012.

Adams, D.C., J. Soto, and F. Escobedo. “Estimating the Supply Of Forest Carbon Offsets: A Comparison Of Best-Worst And Discrete Choice Valuation Methods.” Paper accepted for presentation at the ACES and Ecosystem Markets conference, Ft. Lauderdale, FL, December 10-14, 2012.

Adams, D.C., “Economic Values of Environmental Services: Water in Florida.” University of Florida Water Institute Symposium, Gainesville, FL, February 15-16, 2012.

Grebner, D.L., O. Joshi, I.A. Munn, S.R. Gruchy, and A. Hussain. Are non-industrial private forest landowners willing to support woody biomass harvesting for bioenergy? Paper presented at 18th international symposium on Society and Resource Management (ISSRM) conference, The University of Alberta, Edmonton, Canada. June 17-22, 2012.

Joshi, O., D.L. Grebner, I.A. Munn, A. Hussain, and S.R. Gruchy. Analyzing landowners' preferred harvesting methods for supplying feedstock to potential wood-based bioenergy industries: A choice experiment approach. Paper presented made at Society of American Foresters National Convention, Spokane, Washington, October 24-28, 2012.

Joshi, O., D.L. Grebner, A. Hussain, and S.C. Grado. Landowner knowledge of and willingness to supply woody biomass for bioenergy in Mississippi. Paper presented at IUFRO 4.05.00-Managerial economics and accounting annual symposium, Knoxville, Tennessee. June 6-9, 2012.

Joshi, O., D.L. Grebner, I.A. Munn, S.C. Grado, R.K. Grala, and J.E. Henderson. An econometric analysis of utilizing unused woody biomass from wood processing facilities in Mississippi. Paper presented at Southern Forest Economics Workers Meeting, Charlotte, North Carolina, March 19-22, 2012.

Joshi, O., D.L. Grebner, I.A. Munn, S.C. Grado, R.E. Grala, and J.E. Henderson. An econometric analysis of utilizing unused wood biomass from wood processing facilities in Mississippi. Paper presented at the Fourth International Faustmann Symposium, Saariselkä, Lapland, Finland, September 9-12, 2012.

Khanal, P. N. and D.L. Grebner. Willingness of nonindustrial private forestland owners to practice optimum carbon sequestration regimes in Mississippi. Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) annual meeting, May 15-16, Atlanta, GA.

Khanal, P. N. and D.L. Grebner. A preliminary effort to evaluate the willingness of nonindustrial private forestland owners to practice optimum carbon sequestration regimes in Mississippi. Southern Forest Economists' Workshop, March 20-21, Charlotte, NC.

Khanal, P., D.L. Grebner, I.A. Munn, S.C. Grado, J.E. Henderson, O. Joshi., and R.K. Grala. Determining Optimum Carbon Sequestration Strategies for Pine Plantations in Nonindustrial Private Forestlands of Mississippi. Poster presented at Society of American Foresters National Convention, October 24-28, 2012, Spokane, WA.

Kreye, M.M., D.C. Adams, F. Escobedo, and J. Soto. "Using best-worst scaling choice experiments to measure preferences for forest conservation programs that protect water quality." Paper accepted for presentation at the ACES and Ecosystem Markets conference, Ft. Lauderdale, FL, December 10-14, 2012.

Kreye, M.M., D.C. Adams, T. Borisova, and F. Escobedo, "Valuing forest conservation and water quality protection programs: A meta-analysis of willingness-to-pay scenarios." PINEMAP Annual Meeting, Atlanta, GA, May 15-17, 2012.

Kreye, M.M., D.C. Adams, T. Borisova, and F. Escobedo, "Willingness to Pay to Protect Well-Conserved Aquatic Systems: A Meta-Analysis." University of Florida Water Institute Symposium, Gainesville, FL, February 15-16, 2012.

Nettleman III, C.A., A. Abd-Elrahman, D.C. Adams, G. Barnes, T. Ruppert, B. Dewitt, and T. Fik, "Modeling Policy Solutions to coastal climate change in Florida." International Federation of Surveyors Working Week – Territory, environment, and cultural heritage. Rome, Italy, May 6-10, 2012.

Soto, J.R. and D.C. Adams, "Estimating the Supply of Forest Carbon Offsets: A Comparison of Best-Worst and Discrete Choice Valuation Methods" (Poster). ACES and Ecosystem Markets Meeting, Fort Lauderdale, FL, December 10-12, 2012.

Soto, J.R. and D.C. Adams. "Estimating the Supply of Forest Carbon Offsets: A Comparison of Best-Worst and Discrete Choice Valuation Methods." Agricultural & Applied Economics Association Meeting, Seattle, WA, August 12-14, 2012.

Soto, J.R. and D.C. Adams, "Attitudes and Willingness to Accept Compensation for Carbon Offset Production in Florida: Application of Best-Worst Choice Modeling." Western Agricultural Economics Association Meeting, Park City, Utah, June 20-22, 2012.

Soto, J.R., D.C. Adams, and F. Escobedo, "Estimating the supply of forest carbon offsets: A comparison on best-worst and discrete choice valuation methods." PINEMAP Annual Meeting, Atlanta, GA, May 15-17, 2012.

Susaeta, A.I., D.R. Carter, S.J. Change. "A generalized economic model for carbon sequestration: Implications for sustainability of forestlands in the U.S. South". The 2nd Forest Science Forum: Forest Management Adapting to Climate Change. Beijing, China, October 13-16, 2012.

Susaeta, A.I., D.R. Carter, S.J. Change, and D.C. Adams. "The impact of hurricane risk on optimal forest management in southern U.S. pine plantations: Application of a generalized Reed

model". The Fourth International Faustmann Symposium**:** Forest Economics under Multiple Challenges. Tunturihotelli, Saariselkä, Lapland, Finland, September 9-12, 2012.

Timilsina, N., W. Cropper Jr., and F. Escobedo, "Assessing trade-offs among different ecosystem services in pine flatwoods of the southeastern coastal plain." Pinemap Annual Meeting, Georgia Tech Hotel & Conference Center, Atlanta, GA, May 15-16, 2012.

→ Provide a short narrative describing any workshops, courses, and/or trainings conducted.

→ Provide a short narrative describing experiments or surveys conducted and/or analyzed. *Highlight in yellow items added to the list in the March 2013 Progress Report.*

D.C. Adams (co-PI), M.M. Kreye (PhD student), and Justin Soto (undergraduate PINEMAP intern) conducted pilot tests of our survey on willingness to pay for forest-based water quality improvement, which will inform the bioeconomic modeling non-market ecosystem services.

D.C. Adams (co-PI) and Jose Soto (PhD student) have finished the second and final wave of surveys to estimate non-industrial private forest landowners' willingness to accept carbon offset payments. The results of this survey will inform landowner adoption of mitigation and adaptation strategies, and our assessment of policies and programs that affect C mitigation in planted pine forests.

Progress Updates: Milestones and Work Plan Tasks

Provide a short narrative describing progress and accomplishments on the year 2 milestones and work plan tasks listed below.

Progress updates are carried over from the November 2012 Interim Report. Please provide additional progress updates as applicable for each milestone and work plan task under the March 2013 Progress Report heading.

Year 2 Milestones

→ Assess policies & programs that may affect C mitigation in planted pine forests (December 2012).

November 2012 Interim Report:

We have completed a draft summary of market-based programs and policies that are likely to impact C mitigation, and have started work summarizing federal and state programs and policies. We have also identified and mapped forest carbon storage hotspots (areas of high carbon storage) and other forest areas with low carbon storage (i.e. coldspots) in the State of Florida and the biophysical and forest management characteristics that are driving these hot/coldspots.

March 2013 Progress Report:

The paper by Escobedo et al. on carbon hotspots and management drivers has been published in 2013 issue of Journal of Environmental Management (Vol 114, Pages 293-302).

→ Regional market impacts based on business-as-usual assumptions (November 2012).

November 2012 Interim Report:

We have assessed the effect of bioenergy demands and supply response on markets, carbon and land use in a three-state region. BAU and biomass demand scenarios were evaluated for AL, FL, and GA. The findings were published in *Forest Science*.

March 2013 Progress Report:

We added welfare calculations to the regional timber market model (SRTS).

→ NPV analysis & regional market impacts of adaptation strategies (July 2012).

November 2012 Interim Report:

We have developed the potential future productivity scenarios in light of climate change. In addition, we have defined some mitigation strategies to reduce the negatives effects of disturbances and climate variations (if applicable) on forest productivity. Such strategies could be incorporated into forest management practices.

March 2013 Progress Report:

An economic framework has been developed and will be applied as soon as we have the information about predicted pine productivity change and carbon accounting under climate change from other Aims.

→ Document landowner adoption of mitigation and adaptation strategies (December 2012).

November 2012 Interim Report:

We have completed a first wave of surveys to estimate willingness to accept carbon offset payments by non-industrial private forest landowners in the southeast.

March 2013 Progress Report:

Survey data have been estimated and analyzed; manuscripts reporting the results are being drafted.

→ Life cycle assessment of wood products within forest and various management strategies (February 2013).

March 2013 Progress Report:

Work in progress.

→ NPV & regional market impacts of altered disturbance risks (November 2012).

November 2012 Interim Report:

We have completed the first draft of a paper entitled "Economics of climate change in optimal forest management in the United States South". We have assessed the economics of forestry in loblolly pine (*Pinus taeda*) stands under the risk of climate change. Specifically we have explored the following research topics: i) the effect of potential changes in forest productivity coupled with increased disturbances due to climate change on the expected economic returns and optimal rotation age for southern NIPF landowners, ii) the impact of silvicultural strategies such as managing tree density to ameliorate the impact of disturbances on optimal forest management, and iii) the effect of disturbance-resistant tree species on optimal forest management, and iv) the impact of climate change in the supply of C stored in commercial timber. This paper is under collegial review before being sent for publication.

March 2013 Progress Report:

Work in progress. Three papers have been submitted to journals.

Year 2 Work Plan Tasks

→ Literature review and summary of ecosystem functions, goods and services (March-May 2012).

November 2012 Interim Report:

Significant progress has been made by D.C. Adams, and we have working papers that summarize ecosystem functions, good and services related to habitat, water quality, carbon sequestration, and recreation. We also finalized literature review on the effects of forest management and ecological disturbance on understory diversity of Florida pine flatwoods. Literature was compiled into a database and model.

March 2013 Progress Report:

Nilesh T., F. Escobedo, W. Cropper: We are currently reviewing literature on the use of genetic algorithm for its use as an optimization tool for in ecosystem management. This tool will be used to optimize different ecosystem services outputs/production functions and assess trade-offs between different level of ecosystem service provision. We are also doing literature review to develop various scenarios and management goals that can be used for optimization analyses.

F. Escobedo and R. Cademus (MS student working for a separate project): We used Florida FIA data, the literature, a simplified water yield mass balance model based on McLaughlin et al. (2012), and an ecosystem service provision level classification framework to examine, in a spatially explicit manner, output levels of carbon sequestration, timber production and water yield provision and their interactions (i.e. synergies vs. tradeoffs) in slash pine ecosystems in north Florida. Literature on ecosystem service "tradeoffs" and "synergies" was compiled as well as on the effect of biophysical drivers (e.g. age, basal area, tenure, silvicultural treatments, disturbance regime) on these interactions.

→ Complete hurricane risk modeling (May 2012).

November 2012 Interim Report:

We have submitted the manuscript entitled "The impact of hurricane risk on optimal forest management in southern U.S. pine plantations: Application of a generalized Reed model" to Journal of Forest Economics.

March 2013 Progress Report:

→ Develop and validate herbaceous richness model (June-August 2012).

November 2012 Interim Report:

We developed a model to predict forest understory herbaceous richness using the existing literature and available USDA Forest Service Forest Inventory and Analysis Data. The model has been validated using an independent data set from pine flatwood sites in Georgia and Florida. Validation statistic such as mean prediction error, percentage error, and mean absolute difference have been used to assess model predictions. The manuscript describing this model will be submitted for review.

March 2013 Progress Report:

We finished developing and validating our species richness model. The results are published in a 2013 issue of Forests (Vol 4(1), Pages 122-136). This richness model was used to predict species richness using Forest Inventory and Analysis data. This will allow us to assess trade-offs between different ecosystem services (i.e. timber, carbon and "diversity").

→ Complete the assessment of implications of carbon sequestration on economic rents for southern forestland owners (July 2012).

November 2012 Interim Report:

We have completed the first draft of a manuscript in which we developed an economic model that incorporate the effect of fluctuating carbon prices, conversion factors to forest products, and proportion of wood that permanently sequester carbon on optimal harvest decision of southern pines.

March 2013 Progress Report:

The paper has been submitted to the Journal of Forest Economics.

→ Conduct trade-off analysis and optimization (September-November 2012).

November 2012 Interim Report:

Florida FIA data from different measurement periods has been matched at the plot and individual trees level. FIA plot data has also been matched with 2000 US Census data. Matched database can be used to determine plot-level tree carbon sequestration and other socioeconomic covariates. We are also reviewing literature to identify methods for optimization modeling and developing genetic algorithm to analyze interactions among ecosystem services (i.e. species richness, carbon storage and timber (in forested ecosystems of Florida's coastal plain. Currently, we are analyzing literature on ecosystem service tradeoffs between carbon, timber and herbaceous richness under different management and disturbance regimes, forest types, and geographic regions

March 2013 Progress Report:

We prepared data for our trade-off analysis using our species richness predictive model. Now we have data on carbon, timber and species richness for each Florida FIA plots and can begin our trade-off analysis upon finalization of our genetic algorithm. Currently we

are identifying different management scenarios for optimization. We are also setting up genetic algorithm using R statistical software.

→ Complete modeling regional market impacts and carbon accounting under the business-as-usual scenario (November 2012).

November 2012 Interim Report:

We will expand from the detailed analysis of three states, to a south-wide analysis that incorporates refined land use change assumptions. The data have been updated to the most recent available (FIA 2011); the model has been updated to allow measurement of welfare impacts from interventions; and the representation of wood product demands is being improved.

March 2013 Progress Report:

The work has been expanded to other states.

→ Complete SPB infestation modeling (November 2012).

November 2012 Interim Report:

We have compiled SPB infestation data from the National Forests in the South. Modeling work is underway.

March 2013 Progress Report:

We have made good progress on modeling the impact of climate change and forest management adaptation activities on SPB infestations. The compilation of SPB, climate, and adaptation data has been completed; preliminary modeling results have been generated.

→ Update summary of policies and programs affecting carbon mitigation; review of SE state programs and markets (December 2012).

November 2012 Interim Report:

This is in progress.

March 2013 Progress Report:

Work in progress.

→ Complete survey instrument (December 2012).

November 2012 Interim Report:

We have completed the design phase of two of the survey instruments (Monroe and Adams; Adams and Soto), and are in the process of completing two others (Grebner et al.; Kreye et al.) to inform assessment of policy alternatives and landowner adoption of adaptation and mitigation tools.

March 2013 Progress Report:

Grebner and Khanal have developed a draft survey instrument for forest landowners. It is currently under review. Monroe and Adams continued analysis of their attitudes and perceptions of climate change survey to Extension professionals. Adams and Kreye completed implementation of a regional survey on the willingness to pay for forest-based water quality program, and data are being analyzed and have been presented to stakeholders.

→ Complete wildfire data in the South for modeling (December 2012-February 2013).

November 2012 Interim Report:

All available wildfire occurrence and extent data for all counties in all southern states has been obtained from Fire Program Analysis at NIFC. Socioeconomic data has been obtained from the Bureau of the Census, Bureau of Economic Analysis, and Bureau of Labor Statistics. Weather and climate data developed for the 2010 USDA Forest Service RPA Assessment (historical data downscaled to the county level) have been obtained. Initial econometric models that will be used to forecast wildfire occurrence and extent have been estimated. Forecast socioeconomic and weather and climate data from the 2010 RPA will be used to develop the forecasts.

March 2013 Progress Report:

Fire forecasts have been developed for ecoregion by state areas using climate forecasts.

→ Assess the economic impact of SPB outbreaks using the SRTS model (December 2012-February 2013).

November 2012 Interim Report:

This is in progress.

March 2013 Progress Report:

This is in progress and we wait for colleagues to provide the data on predicted climate change.

→ Analyze and refine optimization (December 2012-February 2013).

November 2012 Interim Report:

This is in progress.

March 2013 Progress Report:

Work in progress. We focus on more trade-off analysis.

→ Complete model development to gauge carbon sequestration in southern pine forests in light of different climate change scenarios including payments and penalties due to carbon sequestration/emissions for plantations (February 2013).

March 2013 Progress Report:

Work in progress.

→ Complete LCA of long-duration wood products (February 2013).

March 2013 Progress Report:

A paper has been submitted to BioEnergy Research.

→ Start to implement survey (February 2013).

March 2013 Progress Report:

See above.

→ Literature review of modeling multiple ecosystem services under climate change phenomena (November 2012-May 2013).

November 2012 Interim Report:

This in progress

March 2013 Progress Report:

Work in progress.