PINEMAP Year 5 Progress Report 1
July 2015
Aim 2 (Modeling)

This is the first Aim progress report for year 5 (covering activity from March 1, 2015- June 30, 2015). 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 REEport progress report.

The purpose of this report is to gather information on progress since the previous progress report in April 2015, and **to prepare for submission of our no cost extension (NCE) in July.**

To streamline this process, information reported in September 2014 (a completed April 2015 progress report was not returned to me) is provided below, so you will simply need to review and update each section as necessary.

Please return the completed report to Grace no later than July 15.

NO COST EXTENSION EXCEPTIONAL CIRCUMSTANCES:

The NCE process requires us to list **work completed** and **work remaining to be completed under the one-year no-cost extension** period (from the original objectives). This should be covered in the narrative below, but please try to be specific about what has been completed to date, what you project will be completed before 2/29/16, and **what would be occurring during the 1 year NCE**.

We must draft a narrative including the **exceptional circumstances** that contribute to the need for the requested no-cost extension. The justification should be compelling such that it demonstrates a bona fide need to convince program staff and the Awards Management Division that the no-cost extension is warranted for successful completion of the award. **Please list your compelling reasons for the work projected to occur during the 1 year NCE, both reasons for delay and improvements in originally planned outputs that will be possible with extra time.**

A key part of our justification will be that in a number of important areas, we need additional time to complete tasks and deliverables, and that the additional time taken will enable us to do a much better job or have a better outcome than we had initially anticipated. **Please consider your aim tasks and those of associated integration platforms, and identify a small number of major tasks or deliverables that fit this model, and write a brief description.** We will use this information in the preparation of our extension application, so **please spend some time discussing this with your colleagues.**

OUTCOMES/IMPACTS

Outcomes and ***Impacts*** are tangible results for stakeholders and society that the project has produced to advance on the societal challenge (e.g., ***changes in knowledge, actions, or conditions*** that result from project activities). Outcomes and impacts are similar, but impacts are typically longer-term; outcomes are used as a nearer-term proxy for impacts.

Describe how Aim-level activities, results, findings, techniques, or products contribute to project-level outcomes and impacts (e.g., changes in knowledge, actions, or conditions resulting from activities).

A narrative has been drafted below. Please modify or update as necessary.

Aim 2 activities contribute to project-level outcomes and impacts by assessing and analyzing how changing management and climate will impact stand and regional carbon sequestration, productivity, and resilience to disturbance. Because climate and management effects on forests span such large spatial and temporal scales, modeling approaches remain the only method available to assess outcomes and impacts for the entire region. Fine scale measurements are transferred using multiple scale models to extrapolate to the region. No update was provided in April 2015

OUTPUTS

Outputs are activities, events, services, and products that reach people.

Products

Products include published or in press peer-reviewed publications; other written materials such as white papers, research summaries, fact sheets, or popular press articles; audio or video products; etc.

The lists below summarize year 4 (March 1, 2014-February 28, 2015) products reported in the September 2014 Progress Report. No update was provided in April 2015.

Please update as necessary and highlight in yellow any products added to the list for the July 2015 Progress Report.

Peer-reviewed publications

Sabatia, C. O. and H. E. Burkhart. 2014. Predicting site index of plantation loblolly pine from biophysical variables. Forest Ecology and Management 326:142-156.

Tor-ngern, P., Oren, R., **Ward, E. J.**, Palmroth, S., McCarthy, H. R. and **Domec, J.-C.** (2015), Increases in atmospheric CO_2 have little influence on transpiration of a temperate forest canopy. New Phytologist, 205: 518–525. doi: 10.1111/nph.13148

Novick, K. A., Oishi, A. C., **Ward, E. J.**, Siqueira, M. B. S., Juang, J.-Y. and Stoy, P. C. (2015), On the difference in the net ecosystem exchange of CO_2 between deciduous and evergreen forests in the southeastern United States. Global Change Biology, 21: 827–842. doi: 10.1111/gcb.12723

Theses/Dissertations

None reported in Sept 2014 report (April 2014-Sept 2014). No update was provided in April 2015

Other publications

None reported in Sept 2014 report (April 2014-Sept 2014). No update was provided in April 2015

Audio/video products

None reported in Sept 2014 report (April 2014-Sept 2014). No update was provided in April 2015

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Events/Activities

Events/activities include presentations (oral and poster) given at meetings or conferences; workshops/trainings/courses conducted; and experiments/surveys/data collection conducted.

The table(s) below summarizes year 4 (March 1, 2014-February 28, 2015) events/activities reported in the September 2014 Progress Report. No update was provided in April 2015. Please update as necessary and highlight in yellow items added to the list for the April 2014 Progress Report.

Presentations

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Ahlswede, B.J. and R.Q. Thomas	Biophysical Climate Effects of Sub-biomes within the Temperate Forest; Implications for Plantation Forestry and Urban Expansion in the Southeastern United States	Poster	Ahlswede, B.J. and R.Q. Thomas	Biophysical Climate Effects of Sub-biomes within the Temperate Forest; Implications for Plantation Forestry and Urban Expansion in the Southeastern United States
Gopalakrishnan, R., V.A. Thomas, J. Coulston, and R.H. Wynne	Producing a canopy height map over a large region using heterogeneous lidar datasets	Poster	Gopalakrishnan, R., V.A. Thomas, J. Coulston, and R.H. Wynne	Producing a canopy height map over a large region using heterogeneous lidar datasets
Ross, C.W., S. Grunwald, L. Kobziar, and S. Gerber	Using DayCent to model ecosystem dynamics in managed pine	Poster	Ross, C.W., S. Grunwald, L. Kobziar, and S. Gerber	Using DayCent to model ecosystem dynamics in managed pine
Wynne, R.	Regional model upscaling	Presentation	May 14, 2014	PINEMAP Annual Meeting, Athens, GA
Sun, G., P. Caldwell, Steve McNulty, Erika Cohen, and Jennifer Moore Myers.	WaSSI: Modeling Impacts of Global Change on Ecosystem Services.	Presentation	April 28-29, 2014.	Carolina Climate Resilience Conf. Charlotte, SC.
Sun, G., S. McNulty, and Y. Liu	Interactions of Climate, Carbon, and Water in the Southeastern Forests	Presentation	Oct 6-11, 2014	2014 SAF National Convention and CIF/IFC AGM & Conference. Salt Lake City, UT
Sun, G., S. McNulty, and Y. Liu	From Forests to Faucets: Water Supply Functions of Forests	Presentation	Oct 6-11, 2014	2014 SAF National Convention and CIF/IFC AGM & Conference. Salt Lake City, UT
Souza, B and R.O. Teskey	Estimating transpiration in loblolly pine (Pinus taeda) plantations using the 3-PG model	Presentation	March 3-4, 2015	18th Biennial southern Silvicultural research Conference, Knoxville, TN

Trainings, workshops, and courses

Ross, CW, presented a CENTURY/DayCent training workshop August 18-22, 2014 in Ft. Collins, CO. This workshop was instrumental to setup DayCent for modeling in PINEMAP. No update was provided in April 2015.

Comment [sg2]: attended

Experiments, surveys, and data collection

None reported in September 2014. No update was provided in April 2015.

PROGRESS NARRATIVE

Provide a brief summary of progress on each deliverable/task/input/output listed below. Please provide a *brief* summary of progress on each deliverable/task/input/output listed below. In many

cases, a one sentence summary may suffice. If there is no progress update on an item, leave blank. Please do not include any figures or tables, but please do include quantifiable measurements, if available (i.e., # of plots measured, # of samples, # of runs, # of people reached, etc.)

Text below summarizes products reported in the September 2014 and April 2015 Progress Reports (March 1, 2014-February 28, 2015)

Please update as necessary and highlight in yellow any new products added to the list for the July 2015 Progress Report, with approximate month of estimated completion.

Regional modeling: 3-PG

Input: Climate and scenarios (8/31/14)
Scenarios have now been developed to guide choices for model runs. Climate data from 20 different models is being processed, allowing for estimation of variability of 3-PG outputs. No update was provided in April 2015.

Task: Model port and testing (8/31/14)
No progress reported Sept 2014. No update was provided in April 2015.

Task: 3-PG FR SI relationship and regional site index categories (8/31/14)
Initial comparison of two models for taking SI to FR complete, preliminary results suggested a need to recalibrate other parameters in 3-PG. Recalibration is ongoing. As an effect of the recalibration, additional parameter sets and SI-FR models are being considered as well. Intiial regional runs will be used to compare pre-determined combinations of parameter sets and models, with emphasis on comparison to existing WaSSI and G&Y baseline results. No update was provided in April 2015.

Task: Regionalization of 3-PG (11/30/14)
Region-wide soil and site index inputs have been extracted and aggregated to the HUC-12 level. Pending climate variables at the same level, it is now feasible to run 3-PG across the PINEMAP region for any year between 1950 and 2100, with likely emphasis being on comparing 1980-1990 with 2060-2070 to facilitate model comparisons between 3-PG, WaSSI, and G&Y.

Task: Climate-based variability assessment (11/30/14)
An assessment of the ability of 3-PG to predict stand growth has been made on sites across the loblolly pine region. A manuscript (Gonzalez-Benecke et al.) been submitted. No update was provided in April 2015.

Deliverable: Baseline runs (11/30/14)
These runs will be possible, once climate data are available and the final selection of parameters has been made.

We have completed WaSSI baseline runs using the MACA climate data (20 GCMs at two RCPs scenarios) from 1951-2099. Maps of climate change impacts on water yield and GPP have been made. Next step is incorporating CO2 effects on water use efficiency and forest leaf area index to project how climate change and co2 concentrations change affect water yield and GPP.

No update was provided in April 2015.

Input: Common validation dataset and climate & scenarios (moved from 2/28/15 to 5/31/15 during 6/2015 meeting)
No progress reported Sept 2014. No update was provided in April 2015.

Task: Model refinement (moved from 5/31/15 to 8/31/15 during 6/2015 meeting)
3-PG now has the effect of CO2 on photosynthesis and stomatal conductance incorporated into it. No update was provided in April 2015.

Task: MCMC parameter estimation (8/31/15, added during 6/2015 meeting)

Task: Flavor bakeoff take 2 (8/31/15, added during 6/2015 meeting)

Task: Refine SSURGO SI map, expand range where feasible (8/31/15, added during 6/2015 meeting)

Output: County level outputs to economics (11/30/15, added during 6/2015 meeting)

Output: To DSS (8/31/15, moved to 2/19/16 during 6/2015 meeting)
No progress reported Sept 2014. No update was provided in April 2015.

Deliverable: Paper (2/29/16, added during 6/2015 meeting)

Regional modeling: Growth and yield

Input: Climate and scenarios (8/31/14)
Climate data from 20 models is pending, allowing for estimates of variability in G&Y predictions. Scenarios will be made to match those for 3-PG and WaSSI. No update was provided in April 2015.

Task: CO_2 fertilization effect (8/31/14)
No progress reported Sept 2014. No update was provided in April 2015.

Task: Expanded sample size for dynamic SI (8/31/14)
No progress reported Sept 2014. No update was provided in April 2015.

Deliverable: Baseline runs (11/30/14)
Initial baseline runs for 1980-1990 and 2060-2070 have been made and presented. These runs cover two management scenarios and two climate scenarios. Pending climate data, further runs will be made, adding estimates of variability to the outputs. No update was provided in April 2015.

Input: Common validation data, climate & scenarios (2/28/15, moved to 5/31/15 during 6/2015 meeting)
No progress reported Sept 2014. No update was provided in April 2015.

Task: Model refinement (8/31/15)
LAI relationships have been provided to WaSSI. This task was omitted from updated timeline.

Task: CO2 fert effect, dynamic SI model finalized (8/31/15, added during 6/2015 meeting)

Task: compare results to validation dataset (8/31/15, added during 6/2015 meeting)

Deliverable: Baseline runs (11/30/15, added during 6/2015 meeting)
Unclear why baseline runs is listed here and as a 11/30/14 deliverable.

Output: To DSS (11/30/15)
No progress reported Sept 2014. No update was provided in April 2015.

Deliverable: Paper (2/29/16 added during 6/2015 meeting)

Regional modeling: WaSSI

Input: Climate and scenarios (8/31/14)
No progress reported Sept 2014. No update was provided in April 2015.

Task: Ecosystem respiration, CO_2 fert model changes (WUE, LAI) (8/31/14)
We developed an ecosystem respiration (ER) model for Loblolly Pine (LP) plantation using 8-years data collected from a drained wetland site on the eastern North Carolina coastal plain. The model can be used to simulate ecosystem respiration with air temperature and soil moisture. We found monthly mean ER is highly correlated with evapotranspiration. The scaling of the transpiration numbers for FACE and should be done with the full ET balance by the end of the August, 2014. Then the NPP/GPP ratio from 3PG to get a WUE for WaSSI.
We are testing several ecosystem respiration models developed from Fluxnet. Improved ER models will be implemented in WaSSI for use in PINEMAP project to understand the tradeoffs between carbon and water. No update was provided in April 2015.

Deliverable: Baseline runs (8/31/14)
WaSSI is ready to receive the MACA climate dataset. We are also testing light use efficiency-based GPP model as an alternative to WaSSI. We applied the WaSSI model to examine historic drought (1961-2012) impacts on US forests, results will be compared to field experiments from PINEMAP. No update was provided in April 2015.

Input: Common validation dataset and climate & scenarios (2/28/15, moved to 5/31/15 during 6/2015 meeting)
No progress reported Sept 2014 No update was provided in April 2015.

Task: Model refinement (8/31/15)
No progress reported Sept 2014 No update was provided in April 2015. Addressed below in next two deliverables.

Deliverable: CO_2 fert WUE (11/30/15, added during 6/2015 meeting)
Literature values CO_2 fertilization (i.e. NPP) impacts are being incorporated into WaSSI. These will be combined by Aim II members Sun, Ward and McNulty with new analyses by Ward of total ET from Duke FACE, themselves based on the same descriptive modeling framework as the Tier 3 sap flux synthesis (see Aim 1 Report). The combination of this information will allow the evaluation of long-term impacts of experimental elevated CO_2 on WUE. This may be contrasted with the lack of 'direct' short-term effects in the same experiment (Tor-ngern et al. 2015) or weak effects noted with change of ambient CO_2 in the control (Novick et al. 2015).

Deliverable: Fertilization and Drought effects on WUE (Post-PINEMAP)

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Model synthesis of Aim I research at Tier 3 sites that will provide more data on fertilization and drought effects on WUE is expected to continue after PINEMAP's official end date or during the no-cost extension year, if granted. The use of a common descriptive modeling framework should greatly facilitate this process.

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Output: To DSS (11/30/15)
No progress reported Sept 2014 No update was provided in April 2015.

Deliverable: paper (2/29/16, added during 6/2015 meeting)

Regional modeling: SRTS

Input: WaSSI baseline (11/30/14)
We have previously worked out the protocol and code to implement growth changes by age, region, and age class and done test runs with WaSSI. No update was provided in April 2015.

Input: G&Y baseline (2/28/15)
No progress reported Sept 2014 No update was provided in April 2015.

Input: 3-PG baseline (2/28/15, moved to 5/31/15 during 6/2015 meeting)
As discussed at the spring meeting we are working with 3PG to refine protocols in anticipation of new runs from these groups. Our 3PG toolbox includes multiple protocols. Bob Teskey et al. have created the 3PG+ model with an accompanying algorithm to estimate FR, the 3PG soil fertility factor that serves to mimic an index of site productivity. David Arthur Sampson created an original version code set (3PGs) of the 3PG model using 3PG+ as the starting point. The 3PGs base model was parametrized using the VPI FMC stand data set (using the Santosh FR algorithm) and validated using the FBRC IMPAC control sites No update was provided in April 2015.

Task: Test runs (5/31/15)
In anticipation of data becoming available in the last phases of the project we have moved our student support funding to a research associate position No update was provided in April 2015.

Output: Aggregate results (8/31/15)
No progress reported Sept 2014 No update was provided in April 2015.

Input: (From economics): Disturbance scenarios (8/31/15)
No progress reported Sept 2014 No update was provided in April 2015.

Output (To regional modeling): Disturbance scenarios (8/31/15)
No progress reported Sept 2014 No update was provided in April 2015.
Input: 3-PG productivity change with change in climate (11/30/15, added during 6/2015 meeting)

Input: Soil C estimates to LCA (11/30/15, added during 6/2015 meeting)

Deliverable: Region wide LCA factsheet: policy making, forest industry models, market solution (11/30/2015, added during 6/2015 meeting)

Deliverable: Region wide LCA product: climate change CO2 policy impact paper (11/30/2015, added during 6/2015 meeting)

Output: To DSS (8/31/15)
No progress reported Sept 2014 No update was provided in April 2015.

Regional Modeling: Community Land Model (section added Sept 2014)

The DAYCENT regional modeling has been replaced with regional modeling using the Community Land Model (CLM) Version 4.5. The CLM is the land model in the Community Earth System Model. We are using the version that includes the CENTURY model as the soil biogeochemistry model, which is also the same soil model in the DAYCENT model that was previously associated with this task. We are running the CLM at the 1 x 1 degree spatial resolution because that is the spatial scale of climate inputs.

Comment [sg3]: I request rewording. The DayCent modeling is a Ph.D. project by Wade Ross (UF), Advisor: Grunwald. And it has not been eliminated from PINEMAP.

I suggest rewording to " The CLM model has been added ….."

Ross is applying DayCent at much higher spatial resolution than the coarse-scale CLM . This allows better characterization of processes and assessment of soil C – climate interactions.

Input: Region wide parameterization (soils, weather, etc.) (8/31/14)
We created a PINEMAP grid that replaces the global grid in the CLM. A grid is the spatial extent and resolution used in the simulation. The PINEMAP grid was used to resample the global input datasets that describe soil physical properties. Currently we are using the default parameterization for a needleleaf evergreen temperate tree to represent a loblolly tree (future work can better parameterize the loblolly tree). The weather inputs used output from Community Climate System Model (a precurser to the CESM) RCP 8.5 scenario simulation. This includes historical output (1850-2005) that used historical data on forcing agents (CO2, land-use, N deposition, solar) and future output (2006-2100) based on the RCP 8.5 scenario. Weather inputs from a RCP 4.5 are also available. No update was provided in April 2015.

Task: Simulate SOC stocks, calibrate model (8/31/14)
To create a map of initial soil organic carbon stocks, we ran the CLM for 1000 years using climate from 1850-1880 and other forcings from 1850 (CO2, N deposition, and land-cover) until an equilibrium was reached. This is a standard modeling protocol for the CLM. No calibration was performed for this project. The CLM was used with default parameterizations except for changing the tree annual mortality rate from 2% to better match the lower mortality in plantation forests (1%). We also modified how harvests are simulated in the CLM by removing all tree boles at harvest and replanting seedlings instead of the default where harvests are a set percentage of existing biomass. Using the equilibrium 1850 initial conditions, we simulated 1850 to 1970 where potential vegetation was replaced with needleleaf evergreen trees and harvested occurred every 25 years. Next we simulated from 1970 to 2100 with harvested every 25-years and wild-fire excluded. No update was provided in April 2015.

Deliverable: baseline runs (11/30/14)
We have model output from 1970 to 2100 from RCP 8.5. Key variables in the the output are the change carbon (vegetation and soil) stocks over each 25-year harvest cycle and the average NPP, GPP, NEP, and Rh over each harvest cycle. No update was provided in April 2015.

Task: Model refinement with respiration data (2/28/15)
We will not refine the CLM with respiration data because it is difficult to perfectly match the environmental conditions at the time that the respiration data was collected. However we plan to compare the model simulated Rh to the observations to better understand whether the model captures the general patterns in the observed Rh.

Input: Forecasting (5/31/15)

We have simulated the RCP 8.5 forecast and plan to simulate the RCP 4.5 forecast. No update was provided in April 2015.

Input: Common validation datasets (8/31/15, added during 6/2015 meeting)

Task: 1970-1993 CRUNCEP run (8/31/15, added during 6/2015 meeting)

Task: Calculate absolute C stocks by adding delta to baseline (8/31/15, added during 6/2015 meeting)

Task: Forecasting with MACA, mgmt scenarios (8/31/15)
Since the CLM requires subdaily weather inputs of many variables, the daily output of the MACA can not be used in the CLM. Though it is important to note the CCSM input data used in the CLM is the data that the MACA used for the downscaled CCSM data. Since the other models (G&Y, 3PG, and Wassi) will also use CCSM data as one of the MACA inputs, we can directly compare the CLM output to the output from other model simulations that use the CCSM MACA inputs. No update was provided in April 2015.

Task: Compare simulated Rh to observations (11/30/15, added during 6/2015 meeting)

Output: to DSS (11/30/15)
The final CLM simulations are still being processed before being delivered to the DSS. No update was provided in April 2015.

Task:
DayCent calibration, validation and simulation modeling to assess regional carbon dynamics. The model has been parameterized and calibrated at tier 3 sites using NPP and soil carbon data. It is now regionalized using space-time inputs, such as climate data, soil, etc. for this model that uses daily time steps. DayCent will be calibrated and validated at tier 2 sites summer/fall 2015 due to delays of tier 2 soil carbon and forest floor measurements that were not available for modeling as of July 2015. After completion of calibration and validation DayCent will be used to simulate carbon dynamics into the future using MACA projections.

Deliverable: Paper (2/29/16, added during 6/2015 meeting)

BROAD IMPACTS

Provide a short narrative describing broad impacts (i.e., far-reaching and possibly unanticipated outcomes resulting from PINEMAP work). Specifically, please highlight leveraged funds and/or partnerships with other projects/external collaborations.

Both carbon and water resources are essential to the sustainability of the South. Our modeling studies provide insights of tradeoffs of among ecosystem services (water supply, timber supply, climate moderation). Climate change adaptation and mitigation measures must consideration all the likely impacts on ecosystems and local economics.
No update was provided in April 2015.

TRAINING

A CUMULATIVE list of all Aim 2 undergraduate and graduate students, postdocs, and technical/research personnel trained under this project and descriptions of their research focus and/or role in the project is provided below. Additions/ changes from the Sept 2014 progress report are highlighted in blue. No update was provided in April 2015.Please update as necessary and highlight in yellow any updates made for the July 2015 Progress Report.

Last name	First name	Position	University	Role
Brooks	Evan	Postdoc	VT	Regional upscaling of growth and yield and 3-PG models for study timeframe and region, initial 3-PG parameter assessment
Cook	Madison	Undergraduate Intern	VSU	2013 Undergraduate Fellow; working with Jose Alvarez at NCSU
Fang	Yuan	Ph.D. Student	NCSU	Using G'DAY model to address nitrogen use efficiency in pine plantations
Gopalakrishnan	Ranjith	Ph.D. Student	VT	Research focus: Downloading and reformatting the NARCCAP scenarios for key climate variables from six models (GCM/RCM combinations)
Gyawali	Nabin	Ph.D. Student	VT	Modeling general response to silvicultural treatments in loblolly pine stands
Ross	Wade	Ph.D. Student	UF	Investigating the response of soil carbon dynamics to changes in climate and fires disturbance in southern pine ecosystems with a process based model
Sabatia	Charles	Postdoc	VT	Investigated growth and yield response to climate and soils variables using Tier 1 data.
Souza	Bruce	MS student	UGA	Modeling loblolly pine plantation water use using 3-PG
Thapa	Ram	Ph.D. Student	VT	Modeling mortality of loblolly pine (*Pinus taeda* L.) plantations.
Wang	Maggie	Ph.D. Student	UGA	Research focus: Working on a research proposal to predict C pool dynamics for alternative land use, management, and climate scenarios at the stand level. The proposal is to link 3-PG and Century to examine forest ecosystem carbon sequestration.
Ward	Eric	Postdoc	NCSU	Measuring and modeling forest water and carbon cycles, including quantifying uncertainty in key processes; working with both Aim 1 and 2 to integrate data and models such as 3PG and WaSSI-C across scales; assisting with data collection and analysis of water fluxes at the Virginia Tier III site.