

TITLE: September 2010 progress report: The influence of mountain pine beetle outbreaks on carbon and nitrogen cycling in lodgepole pine ecosystems

LOCATION: Central and northern U.S. Rockies

DATE: 24 September 2010

DURATION: 2 of 4 year project (JVA with Utah State University funded year 1)

FUNDING SOURCE: Base

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PROJECT OBJECTIVES: Using chronosequence measurements and simulations, to characterize and quantify the influence of mountain pine beetle (MPB) outbreaks in lodgepole pine (LPP) systems regarding: 1) carbon (C) flux and storage; and 2) nitrogen (N) cycling and retention among ecosystem components (aboveground vegetation, downed woody material, and soil compartments).

JUSTIFICATION:

- a. **Linkage:** The field plots for this project are based on FIA protocols, including Phase 3 soil and forest floor sampling. Compatibility with FIA data (within LPP type) allows potential use of FIA data to expand the project's scope. Plot locations were chosen based on FHP aerial pest detection surveys.
- b. **Significance:** MPB outbreaks are a significant disturbance type in LPP and the results of this proposed project can be applied throughout western North America with emphasis in the U.S. Rockies.
- c. **Biological impact and Political Importance:** Major MPB outbreaks are reported across western North America. Stand conditions and climate change have been implicated as major factors for such wide spread outbreaks. The U.S. Congress has introduced bills related to promoting C sequestration and future C credit markets. The 2009 National Silviculture Workshop emphasized Biomass, Climate, Carbon Sequestration. This project would provide additional information to managers regarding the C and N cycles in western LPP forest and how MPB outbreaks may affect those cycles.
- d. **Scientific Basis/Feasibility:** Field plot establishment is complete; a Joint Venture Agreement with Utah State University funded the majority of plot establishment costs with RMRS contributing salary. EM funding is being requested to fund flux device retrievals, collect tissue samples, and conduct lab analyses. Most of the project is based on FS standards (FIA, FVS). RMRS has a strong reputation for completing projects and reporting results.
- e. **Priority Issues:** This project aims to address changes in LPP forest health, productivity, and function resulting from MPB outbreaks as well as outbreak-related changes in soil conditions. Also, the results will enable assessment of cascading effects on forest functioning due to climate change- and drought-related MPB population dynamics. Moreover, estimates will be improved regarding global C storage and flux in relation to MPB outbreaks.

DESCRIPTION:

a. Background: Possible influences of MPB outbreaks on C and N dynamics can be hypothesized by considering a LPP developmental chronosequence following a stand replacing event. As the landscape is re-colonized, increment (C uptake, *i.e.*, photosynthesis) slowly increases, reaching a maximum from age 30-60 years then slowly declines over the life of the stand, a pattern widely observed in forested systems. Without further disturbance, annual increment will decline to a fraction of its maximum value

and live volume will approach some asymptotic value. Meanwhile, N dynamics are tied to the C cycle. Autotrophic nutrient demand is greatest during maximal biomass increment. Thus, relatively young stands should maximally retain N whereas mature stands are more likely to have increased N losses via leaching. Contrast this to an otherwise similar LPP chronosequence with a cycle of MPB outbreaks every 40-60 years beginning at stand age 100. The resulting death of overstory trees initiates a chain of events that modify C and N accumulation, storage, and retention. Understanding these cycles will enhance managers' ability to match vegetation and MPB management with desired outcomes regarding stand productivity, N availability/retention, and C sequestration.

b. Methods: A variety of methods will be used to measure and simulate C and N dynamics during LPP development, with and without MPB disturbance and at multiple temporal and spatial scales.

Empirical data Forty-one field plots were established in 2009 at three regions (northeast UT, central ID, and near Yellowstone NP) representing a variety of MPB history and LPP development. These plots, based on FIA "Phase 3" plots but with additional flux measurements, are intended to quantify stand-level C and N pools and fluxes. Tissue samples will be taken from the various vegetation types, live and dead, and analyzed for C and N concentrations. C and N pools and fluxes will be directly compared among infested and uninfested areas.

Simulation models Two simulation models, FVS (Forest Vegetation Simulator; an empirical growth and yield model) and FVS-BGC (links FVS with Stand BGC, a process-based, C balance model), will be used to simulate chronosequences of LPP stand development, with and without MPB disturbance. Simulations will aim to track C storage and fluxes from stand establishment through multiple centuries of development. N pools and fluxes will also be estimated using information gathered from the field plots in conjunction with allometric equations.

Remote sensing Light use efficiency (LUE) models based on remotely sensed data are widely used to estimate landscape- and global-scale gross and net primary production (GPP and NPP). These models, however, do not address stand age-related declines in productivity. We will use the 3PGS model (Physiological Principles Predicting Growth from Satellites) which couples elements of empirical growth and yield models with process-based, C balance models. In addition to using LUE-type input, 3PGS uses a stand age-dependent growth modifier. Assessment of MPB disturbance effects on C dynamics, as estimated by 3PGS, will consider MPB history based on ground and Forest Health Protection aerial detection survey data.

c. Products: Peer-reviewed articles and presentations at conferences (e.g., Western Forest Insect Work Conference). Managers can use this information to model vegetation treatments for any possible "beneficial" affects of MPB outbreaks as well as mitigate any possible "detrimental" affects.

d. Schedule of Activities:

Summer 2010:

Final flux measurements at field plots; collect tissue samples.

Fall 2010 and winter 2011:

Lab analyses of flux and tissue samples.

Obtain satellite-based data and associated ground data.

Run FVS and 3PGS simulations.

Spring and summer 2011:

Construct complementary chronosequences from field plots, FVS, and satellite-based simulations.

Fall 2011 and winter 2012:

Manuscript preparation and submission.

ACCOMPLISHMENTS (FY 2010): Flux measurements: 1) above and belowground ion exchange membranes (IEMs) were retrieved from all field locations; 2) litterfall trap contents were collected; 3) downed woody material (DWM) transects were re-measured after one year. IEMs and litterfall will be analyzed by Dr. Michael Amacher's laboratory beginning Fall 2010 with soil sample analyses nearing completion as of this writing. Also, an *in situ* decomposition study was added to the project with the deployment of litterbags, tongue depressors, and cohort layered screens at all plots. Tissue samples

were taken from a subset of field plots including: 1) foliage, bark, and stem wood from over- and understory trees; 2) DWM of various decay classes; and 3) whole-plant sampling of seedlings as well as representative grasses, forbs, and shrubs. Finally, field data have been prepared for analyses using FVS and FVS-BGC. In summary, the project is on schedule and without complicating factors.

COSTS:

	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR 2010				
Administration	Salary	15,000	32,500	RMRS
	Overhead	1,848		
	Travel	2,000		
Procurements	Contracting	7,000		
	Equipment		3,000	USU-JVA
	Supplies		5,000	USU-JVA
Total		25,848	40,500	

	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR 2011				
Administration	Salary	18,500	35,000	RMRS
	Overhead	1,425		
Procurements	Contracting			
	Equipment			
	Supplies		2,000	USU-JVA
Total		19,925	37,000	

	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR 2012				
Administration	Salary		20,000	RMRS
	Overhead	154		
Procurements	Contracting	2,000		
Total		2,154	20,000	

Grand total (3 years)		47,927	97,500	
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Specifically, requested funds will be used to support: 1) a field technician (summer 2010) and lab technician (fall 2010 and winter 2010/2011); 2) travel for Hansen and the technician; 2) leased vehicle and associated fuel costs for travel to field sites. RMRS charges 7.7% overhead on intra-agency transfers. An additional \$2,000 is requested for FY 2012 to pay for journal page charges. Thus, the total request is \$47,927.

Literature cited and preliminary results available upon request.