Annual Report (2003-2004)
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Project Title: Carbon Flux and Storage in Mixed Oak Forests of MOFEP
Principal Investigators: Jiquan Chen and Daryl Moorhead (University of Toledo)
Collaborators: Randy Jensen (DDC) and John Kabrick (USDA FS)

The primary objective of this study is to quantify differences in carbon flux and storage in mixed oak forests of the Southeastern Missouri Ozarks in response to management practices, landscape form, and climate change. The experimental compartments of MOFEP will be used to collect empirical data for predicting net carbon exchanges (NCE ~ net ecosystem productivity) at multiple temporal scales (monthly to century). These predictions will be extended to provide a spatial context of NCE and C storage using processed Landsat imagery, in conjunction with ecological land type phases (ELTP) and digital elevation model (DEM) databases.

The four major tasks of this project are: (1) to quantify carbon flux and storage in MOFEP compartments and dominant ELTPs using conventional biometric methods; (2) to parameterize production and decomposition models (i.e., PnET and GENDEC) with site-specific measurements from MOFEP compartments and dominant ELTPs, (3) to simulate changes in NCE and C storage over 100-year periods, and (4) to measure carbon flux in the field for testing model performance and increasing model precision. Since July 2002, we have primarily focused on field data collection, preliminary data analysis and collaboration with other ongoing projects for manuscript preparation.

We have completed field data collection of soil respiration, photosynthesis of dominant tree species, litter decomposition and associated lab analysis (e.g., chemistry), litter-fall, root biomass, soil chemistry (lab processing), soil temperature, as well as established two new microclimatic stations. All data have been added to the MOFEP Database (http://mofep.conser-vation.state.mo.us/. Hemispherical photos of the MOFEP compartment were archived in 5 CDs and mailed to the MOFEP Coordinator (Dr. Dave Gwaze). Three peer-reviewed publications, two submitted manuscripts, and one M.S. Thesis have been completed, which utilize results of our work to date. Five presentations also have been made at scientific meetings (e.g., ESA Annual Meetings). Both the PnET and GENDEC models are being customized for the MOFEP study. The interactive version of PnET model already is available at http://research.eeescience.utoledo.edu/lees/research/jfsp/model/pnet/pnet_step1.asp, allowing any user to run the model via the Internet. Six Landsat TM images (2003, 1996, 1992, 1984, and 1976) have been purchased through collaborations with the JFSP

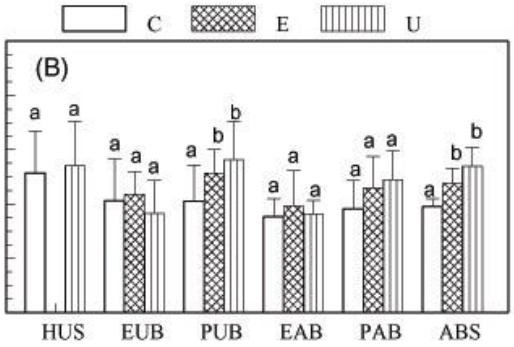

Fig. 1. Mean and standard deviation of soil respiration rate patch type and treatment type. Patch types at MOFEP were high ultic shoulder/shldr-ridge, bench (HUS), exposed ultic back-slope (EUB), protected ultic back-slope (PUB), exposed alfic back-slope (EAB), protected alfic back-slope (PAB), alfic bench or shoulder-ridge(ABS).

project (Chen). Image processing is under way to predict changes in biomass across Ozark Landscapes 1970-2003.

Soil respiration is a major source of carbon efflux in forests, averaged 4.14 µmol m^{-2} s^{-2} at MOFEP, and was significantly different by site and management within site (Fig. 1, F=43.23, P=0.0012; F=10.21, P=0.0026, respectively). Clearcuts and single-tree removal had different effects on soil respiration rate. Respiration in clearcut soils was not significantly different from the controls, but was elevated by single tree-selection. Soil respiration also was significantly different among ELTP; meanrespiration with single-tree harvest increased compared to control in protected ultic back-slope sites, protected alfic back-slope, and alfic bench or shoulder-ridge sites, and decreased exposed ultic back-slope and exposed alfic back-slope sites.

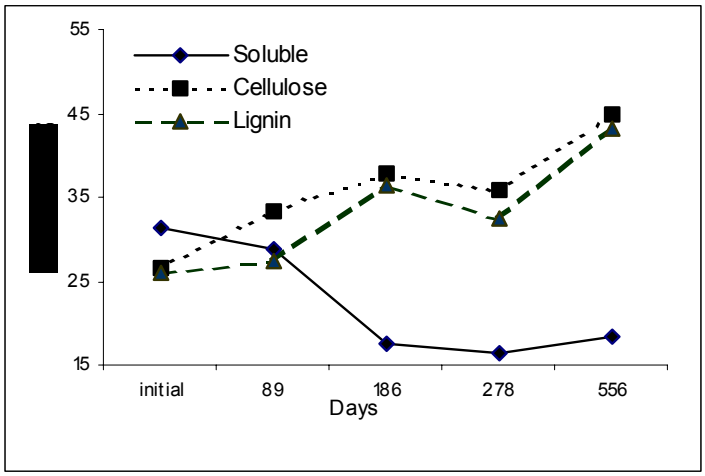

Fig. 2. Changing chemistry of decaying leaf litter during the study period.

Leaf litter decomposition was the major carbon input from living carbon pool to soil carbon pool. The litterbag study demonstrated that the 50.2% of mass was lost through decomposition after 580 days. Litterbag chemistry analysis shows that the three major carbon components, soluble, cellulose, and lignin, varied during the incubation. The soluble fraction decreased from 31% to 18% during this period (Fig 2), whereas cellulose and lignin fractions increased. Surprisingly, the ratio of cellulose and lignin varied little during this period, demonstrating a lower than

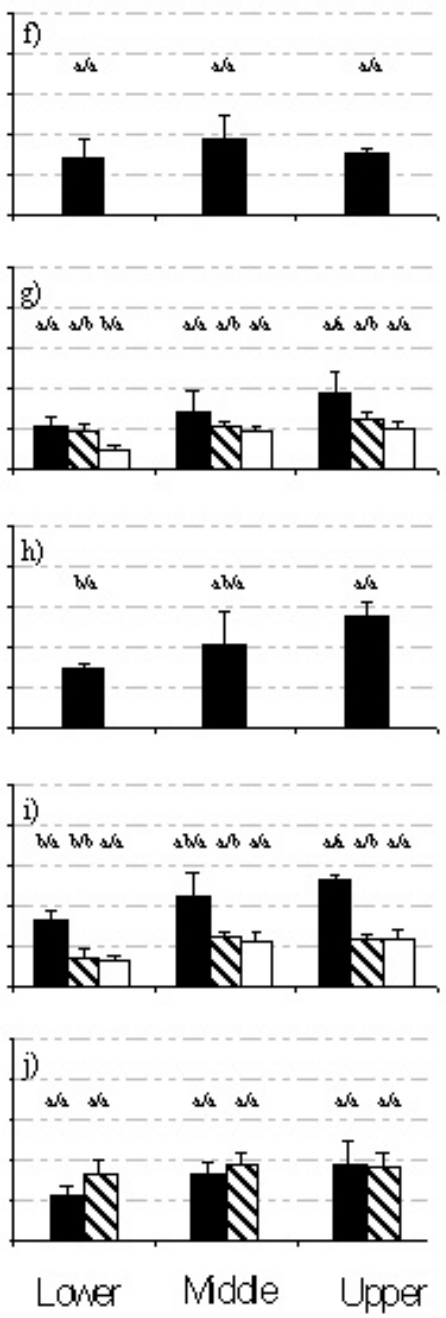

Fig. 3. Stomata conductance ($g_{s,max,}$ µmol m^{-2} s^{-1}) of major species by canopy position and age structure. Black indicates mature stands, stripped indicates intermediate and white indicates young stands. (f) shortleaf pine, (g) scarlet oak, (h) black oak, (i) white oak, and (j) hickory.

expected relative rate of cellulose decay. Comparable results in an independent study being conducted in Manistee Forest (Michigan; Moorhead) were found for low-nutrient litter decay on low nutrient-sites. These results suggest low nutrient availability in some MOFEP units.

Photosynthesis is the major carbon sink in forest ecosystem, and was measured in major species on MOFEP sites (white oak, black oak, scarlet oak, hickory and short leaf pine) at three different age classes: young (<10 years), intermediate (15-25 years), and mature (>80 years); and at three canopy levels (upper, middle and lower, Fig. 3). The average photosynthetic rate among all species under control conditions (1500 μmol photons m^{-2} s^{-1} PAR and 360 μmol/mol ambient CO_2) was 7.97 and 8.23 μmol C m^{-2} s^{-2} for Aci curve and light response curves, respectively. The average maximum photosynthetic rate among all the species was 19.7 and 8.46 μmol C m^{-2} s^{-2} for the CO_2 and light response, respectively. Upper canopy positions typically showed greater photosynthetic capability than lower positions, for all species ($p<0.0001$ to 0.0125). Specific leaf weight was the best predictor of photosynthetic rate among measured factors (SPAD chlorophyll concentration, vapor pressure deficit, temperature, and fraction of PAR intercepted).

Research plans include continuing field data collection, maintaining the two weather stations, updating data archives for MOFEP, and data analysis for publications. We have field data for two full growing seasons in 2003 and 2004, as well as an extensive litter decomposition study spanning more than 2 years. Another season of field-work would greatly enhance the value of this study by providing sufficient data to establish a level of inter-annual variation in ecosystem behavior (n=3 years). We have planned the following activities:

- Monthly soil respiration measurements at 62 selected plots.
- Monthly litter-fall collection from 104 litter traps.
- Monthly maintenance and data acquisition from 36 HOBO dataloggers.
- Bi-weekly maintenance and data acquisition from the 2 microclimate stations.
- Hemispheric photos at 36 vegetation plots and along, five 100 meter tansects
- Hemispheric photos at 104 hardmast traps.
- Organizing the database of overstory, litter-fall, CWD, soil total carbon, and ground litter for quantifying carbon pools.
- Conducting mass loss and chemistry analysis of litterbags from the last scheduled collection in summer 2005.
- Measuring foliar C and N content using a CHN Analyzer at the LEES lab.
- Parameterizing PnET and GENDEC models for modeling studies.
- Processing 5 Landsat TM images

Data analysis and manuscript development will be our primary focus for 2004/2005:

- Alterations of silvicultural treatments on carbon pools at MOFEP Forests (*Ecol. Appl.*).
- The effects of canopy removals on soil C efflux in mixed oak forests (*For. Ecol. Manage.*).
- Contributions of decomposition to ecosystem carbon flux and storage in mixed oak forests of the Missouri Ozarks (*Ecol. Modelling*).
- Changes in above ground biomass in Ozarks: 1975 – 2003 (*Rem. Sensing of Environ.*).
- Spatial variations of soil carbon fluxes affected by experimental treatments (*Plant & Soils*)
- Current and future carbon fluxes of Ozark Landscapes: a modeling approach (PnET).