Post Fire, Carbon, Energy and Water Dynamics of a Naturally Regenerated Pine Ecosystem in Northeastern Florida

Greg Gorman

October 20, 2006

Project Summary

Southern pine plantations comprise of approximately 5.35 x 10^6 hectares and on average is the highest region of net uptake and accumulation of carbon. This forest type is dominated by the *Pinus* genus and occurs in a combination of even aged single species managed plantations, and uneven aged multiple species naturally occurring forests. Prescribed fire has long been used as a tool for pine stand management in the region. In mono specific plantations fire is used to remove residual woody biomass which remains on site after a harvest, and to prepare the site for the next rotation of crop trees. Mixed uneven aged pine forests usually have a different management objective. The value is placed on the historical and atheistic benefits offered to society, not the economic gain of the harvested trees. Fire in this system is used to maintain the growth of the forest over time. The vegetation of the overstory and understory, of both systems, have a great tolerance to fire, and many species are maintained by its periodic occurrence. However, little information exists on how periodic prescribe fire impacts carbon, water, and energy dynamics in this ecosystem.

The objective of this proposal is to further understand the mechanisms which control post fire ecosystem carbon, water, and energy dynamics, and to better understand environmental constraints on the net ecosystem productivity. This study will maintain measurements of eddy covariance and associated ecosystem fluxes as part of an ongoing long term study in this naturally regenerated *Pinus palustris* and *Pinus elliottii* mixed stand.

Project Description

Forested ecosystems play an important role in the global carbon balance due to their widespread distribution and their ability to sequester carbon in perennial tissues and soil. These ecosystems are in a constant state of change, and have the ability to respond to different factors which affect their carbon storage status (Clark et al. 2004). For example, climate variations (e.g. growing season length, growing season temperature, and annual precipitation), disturbance (e.g. fire, insect-induced mortality, and harvesting), and changes in atmospheric chemistry (atmospheric CO_2 concentrations and nitrogen deposition) can produce a positive or negative feedback of carbon in these ecosystems (Chen et al. 2000). In the global carbon balance, forests account for more than 75% of the carbon stored in terrestrial ecosystems and approximately 40% of the carbon exchange between the atmosphere and the terrestrial biosphere each year (Schlesinger 1997). In the United States, this ecosystem receives a consider amount of interest in the potential for sequestering atmospheric carbon (Hamilton et al. 2002) because it is the largest land use type. In 1997, a government report estimated forest land use to be 28% (642 million acres) of the total land area, and each year this number increases as more land is converted from cropland to forestland (Vesterby, 1997). Within this extent, Southern pine flatwoods forests have the largest potential accumulation of carbon, and on average is the highest region of net uptake per unit area (Tuner et al. 1995). Regionally this ecosystem is comprised of approximately 5.35×10^6 hectares (Smith et al. 2001), and on a state level, it accounts for about half of Florida's terrestrial landscape (Myers and Ewel 1990). This forest type is dominated by the *Pinus* genus and occurs in a combination of even aged single species managed plantations, and uneven aged multiple species naturally occurring forests. In general, (pine) flatwoods stands are characterized by a relatively open overstory of pines, an extensive low shrub stratum, and a variable and often sparse herbaceous layer (Myers and Ewel 1990).

Single species plantations, in the South are typically comprised of either *Pinus elliottii* (slash pine) or *Pinus taeda* (loblolly pine), and are intensively managed (Clark et al. 2004) for the production of wood fiber (Gholz, Clark 2002). They are characterized by a continuous but shallow canopy of slash pine with a clear understory comprised primarily of *Serenoa repens* (saw palmetto), *Ilex glabra* (gallberry), and *Myrica cerifera* (wax myrtle) (Gholz et al. 1999). Prescribed fire in pine plantations are normally not considered as a management tool except for site preparation and stand establishment. Post mechanized harvested sites usually have residual branches, foliage, and understory vegetation which are raked into slash piles and burned (Clark et al. 2004) to facilitate planting of the pine seedlings (Crutchfield, Martin 1982).

Still present amidst the pine plantations of the south are mixed uneven aged pine forests. Although not large in extent (Gholz, Fisher 1982), these forests pose a valuable asset to the heritage of the Southeastern pine community. Typically it is composed of a mixture of *Pinus palustris* (longleaf pine) and slash pine, but may contain a varity of hardwood species. Similar to plantations, the understory in this system contains saw palmetto, gallberry, and wax myrtle. Also present in this stratum are *Aristida stricta* (wiregrass), *Vaccinium myrsinites* (ground blueberry), *Lyonia lucida* (fetterbush), and *Vaccinium stamineum* (deerberry) (Myers and Ewel 1990). This system is comparable to southern pine forest prior to European arrival, and attempts to maintain it as such, continue.

Pre-European southeastern pine forests were old growth open canopied systems which were dominated by the longleaf pine forest type (Platt et al. 1988). Chronic, non-catastrophic fires have long been recognized as influencing the vegetation dynamics in this system (Drewa et al. 2002). In old growth savannas, such fires affected the structure of the longleaf overstory (Platt et al. 1988), and stimulated growth of species in the ground cover (Streng et. al 1993). After settlement in this region, virgin longleaf pine forests were extensively exploited (Tebo 1985), and fire was suppressed.

Prescribed fire has long been used as a tool for pine forest management. Only over the past couple decades, however, have prescribed fires mimicked the frequent, lighting-initiated fires that were historically an integral part of the environment (Platt et al. 2006). In general, such fires are restricted to the ground surface and are characterized by low temperatures and intensities, and relatively rapid rates of spread (Glitzenstein et. al 1995). Prescribed fires can maintain the system in a non-successional phase by reducing or removing dead woody debris, the understory component of the system, and removes or reduces the amount of litter on the forest floor (Keeley et al. 1988). The vegetation of both the overstory and understory, have a great tolerance to fire, and many species are maintained by its periodic occurrence (Abrahamson 1984a). Many of the understory plant species such as saw palmetto and wiregrass are highly flammable, and a complete and even burn of the stand usually occurs due to the fire carrying capacity of these plants (Myers and Ewel 1990). The majority of the understory plants maintain underground stores of carbon which enable them to recover more quickly after a fire. The timing of the fire also has an affect on the dynamic of these stands. Repeated dormant season fires, generally increase stem density of shrubs (Drewa et al. 2006), which can increase the productivity of the system. Conversely, periodic fires during the growing season can reduce the above ground biomass of the lower component and over time will remove various species from the system.

References

Abrahamson, W.G. 1984. Post-fire recovery of Florida Lake Wales Ridge vegetation. American Journal of Botany 71:9-21.

Beckage, B., W.J. Platt, B. Panko. 2005. A climate-based approach to the restoration of fire-dependent ecosystems. Restoration Ecology 13:429-431.

Chen, W., Chen, J., Cihlar, J. 2000. An integrated terrestrial ecosystem carbon-budget model based on changes in disturbance, climate, and atmospheric chemistry. Ecological Modelling 135, 1: 55-79.

Clark, K.L., H.L. Gholz, M.S. Castro. 2004. Carbon dynamics along a chronosequence of slash pine plantations in North Florida. Ecol Appl. 14:1154-1171.

Christensen, N.L. 1981. Fire regimes in southeastern ecosystems. Proceedings of a Conference: Fire regimes and ecosystem properties. USDA For. Serv. Gen. Tech. Rep. WO-26.

Crutchfield, D.M., J.P. Martin. 1982. Site preparation- Costal Plain. In Proceedings of Loblolly Pine Ecosystem (East Region) Symposium. USDA For. Ser. SE For. Exp. Sta. 49-57.

Drewa, P.B., W.J. Platt, E.B. Moser. 2002. Fire effects on resprouting of shrubs in headwaters of southeastern longleaf pine savannas. Ecology 83: 755-767.

Drewa, P.B., J.M. Thaxton, W.J. Platt. 2006. Responses of root-crown bearing shrubs to differences in fire regimes in *Pinus palustris* (longleaf pine) savannas: Exploring old-growth questions in second-growth systems. Applied Vegetation Science 9:27-36.

Gholz, H.D., R. F. Fisher. 1982. Organic matter production and Distribution in slash pine (*Pinus elliottii*) plantations. Ecology 63:1827-1839.

Gholz, H.L., D.N. Guerin, W.P. Cropper. 1999. Phenology and productivity of saw palmetto (*Serenoa repens*) in a north Florida slash pine plantation. Canadian Journal of Forest Resources 29:1248-1253.

Gholz, H.L., K.L. Clark. 2002. Energy exchange across a chronosequence of slash pine forests in Florida. Agricultural and Forest Meteorology 112:87-102.

Glitzenstein, J.S., W.J. Platt, D.R. Streng. 1995. Effects of fire regime and habitat on tree dynamics in North Florida longleaf pine savannas'. Ecological Monographs 65:441-476.

Hamilton, J.G., DeLucia, E.H., George, K., Naidu, S.L., Finzi, A.C., Schlesinger, W.H.

2002. Forest carbon balance under elevated CO2. Oecologia 131, 2: 250-260

Keeley, J.E., S.C. Keeley, 1988. North American terrestrial vegetation. Cambridge University Press, New York, New York.

Myers, R.L., J.J. Ewel. (Editors). 1990. Ecosystems of Florida. University of Central Florida Press, Orlando, Fl.

National Climatic Data Center. 2004. Climatic data, Gainesville Regional Airport, Gainesville, Florida. National Oceanic and Atmospheric Administration, Asheville, N.C.

Platt, W.J., G.W. Evans, S.L. Rathbun. 1988. The population dynamics of a long-lived conifer (*Pinus palustris*). The American Naturalist 131:491-525.

Platt, W.J., S.M. Carr, M. Reilly, J. Fahr. 2006. Pine savanna overstory influences on ground-cover biodiversity. Applied Vegetation Science 9:37-50.

Powell, T.L., G. Starr, K.L. Clark, T.A. Martin, H.L. Gholz. 2005. Ecosystem and understory water and energy exchange for a mature, naturally regenerated pine flatwoods forest in North Florida. Can. J. For. Res. 35:1568-1580.

Rebertus, A.J., G.B. Williamsom, W.J. Platt. 1993. Impacts of temporal variation in fire regime on savanna oaks and pines. Proceedings of the Tall Timbers Fire Ecology Conference 18.

Schlesinger W.H. 1997. Biogeochemistry: an analysis of global change, 2nd edn. Academic, New York.

Smith, W.B., J.L. Vissage, D.R. Darr, R. Sheffield. 2001. Forest resources of the United States. USDA For. Serv. Gen. Tech. Rep. GTR-NC-219.

Streng, D.R., J.S. Glitzenstein, W.J. Platt. 1993. Evaluating season of burn in longleaf pine forest: a critical literature review and some results from an ongoing long-term study. Proc. Tall Timbers Fire Ecology Conference 18:227-263.

Tebo, M. 1985. The southeastern pineywoods: describers, destroyers, survivors. Master’s thesis Florida State University, Tallahassee.

Turner, D.P., G.J. Koerper. 1995. A carbon budget for forest of the conterminous United States. Ecological Applications 5:421-436.

Vesterby, M., Krupa, K., S. 1997. Major uses of land in the United States. U.S. Department of Agriculture, Statistical Bulletin 973.