CARBON DYNAMICS OF SELECTED ECOSYSTEMS ON MANAGED CONSERVATION AREAS IN THE NORTHERN EVERGLADES WATERSHED

Presented by C. Ross Hinkle
University of Central Florida

Collaborators:
“Hold Your Breath” for A Bit of Background
Global atmospheric concentration of CO₂

I was born!
Some Consequences of Global Climate Change to Florida?

- Weather “weirding”
  - Average global temperature increased by @1.2 degrees over past century
  - More heat waves
  - Coastal flooding
  - Fewer but stronger hurricanes
  - More extreme droughts
  - Northern shift of freeze line
Consequences (cont.)

- Wildfires – extreme droughts, more extreme wildfires (remember 1998; this year?)
- Wildlife
  - Northern shift of species (including invasive species)
  - Marine life responses to warmer ocean
  - Increase in ocean acidity
  - Bird species loss (Florida Grasshopper Sparrow, Florida Scrub Jay?)
  - Algal blooms
Consequences (cont.)

• Beach erosion:
  – Rising sea level (19 of 20 Floridians within 35 miles of coast (rise of ??? by centuries end)
  – Shift of mangrove communities
  – NWF report 49% loss of ocean beach, 15% loss of upland and 11% loss of hardwood swamp within IRL region (MINWR is one of the most at risk)

• Agriculture (increased agricultural production due to fewer freezes and greater atmospheric CO$_2$??)
Overarching Objective

“understand and quantify regionally specific effects of ongoing and future climate change on structure and function of terrestrial ecosystems including feedback between ecosystems and climate change”

DOE Terrestrial Ecosystem Science Programmatic Objective.
Central Florida Projects were “launched” in Scrub Oak Vegetation at Kennedy Space Center.
Major question - KSC elevated CO$_2$ study

What is the capacity for land ecosystems to sequester carbon and partially mitigate climatic change?
16 Experimental Chambers

8 Ambient Chambers

8 Elevated Chambers (Ca +350ppm)

8 Unchambered sites
Some Key Findings
(Seiler et al. 2009 after 11 years (1996-2007)

- Aboveground shoot biomass increased 67% with elevated CO$_2$
- Biomass stimulation was driven by *Q. myrtifolia* and *Q. geminata*; *Q. chapmanii* showed no significant CO$_2$ response
- Water stress in *Q. myrtifolia* was ameliorated by elevated CO$_2$
- Interannual variation in above ground growth was correlated with annual rainfall
Some Key Findings
(Seiler et al. 2009 after 11 years (1996-2007))

- Overall growth stimulation was sustained for 11 years but considerable interannual variability
- Absolute growth stimulation was generally declining (possible environmental limitations with interactions of rainfall, nutrient availability and elevated CO₂, Hungate et al. 2005)
- Hurricane defoliation in 2004 was followed by strong increase in shoot density in 2005 (Li et al. 2007)
• Water use efficiency:

  – Elevated CO$_2$ reduced transpiration in all species tested (Lodge, et al. 2001; Li et al. 2003)

  – Reduced transpiration results in more soil water (Hungate, et al. 2002)

  – Both scrub and pine flatwoods systems maintained significant ET even during drier conditions in upper soil horizons because of access to shallow water table (Bracho et al. 2008)
Additional findings (cont.)

- Growth of fine and coarse roots:
  - Dilustro et al. 2002; Day et al. 2006; Brown et al. 2008; have shown transient effects of elevated CO$_2$ on fine root growth and Stover, et. al. 2007 using ground penetrating radar, have shown increase in coarse roots under elevated CO$_2$. 85% of system total biomass was belowground in the scrub oak.

- Johnson et al. 2003 showed elevated CO$_2$ caused greater accumulation of carbon and nutrients in both vegetation and O-horizon over a 5 year period.
Additional findings (cont.)

• Stiling et al. 2002: increased levels of CO$_2$ are likely to affect trophic relationships that exist between plants, herbivores and natural predators of the herbivores.

• Alexis et al. 2006: post-fire charcoal production ranged from 4-6% of fire affected biomass (charcoal + atmospheric loss) which is below literature values of stable soil organic matter that is produced thru humification processes suggesting that fire generates a smaller quantity of stable organic C than humification processes over long time periods (decades to centuries?)
Ecosystem Gas Exchange: Eddy Flux and Chambers

Dore, et al. 2003, Global Change Biology 9, 84-95
(Video courtesy of Matt McClellan FAU)
Selected Results from Gas Exchange Studies at Disney Wilderness Preserve (DWP) and Blue Cypress Marsh (BCM)

Three Sites:

- DWP - Longleaf pine flatwoods (6 years)
- DWP - Depression/seepage marsh (3 years)
- BCM - Sawgrass peat marsh (6 years)
**Net Ecosystem Exchange**

**Pine Flatwoods at DWP**

96 g C m\(^{-2}\) uptake (annual average @1 metric ton/ha/yr @0.4 tons/ac/yr)

**Depression Marsh at DWP**

131 g C m\(^{-2}\) uptake (annual average @1.3 metric tons/ha/yr @0.6 tons/ac/yr)

**Peat Marsh at BCM**

177 g C m\(^{-2}\) uptake (annual average @1.8 metric tons/ha/yr @0.8 tons/ac/yr)

**Fire event**
Methane Emissions

Depression/Seepage Marsh at DWP
- 66 g C m$^{-2}$ annual average

Peat Marsh at BCM
- 38 g C m$^{-2}$ annual average
Fire is an important component of the global carbon cycle:

- Releases 1 Gt C y$^{-1}$ globally (Li et al. 2014)
- Volatilizes plant biomass and soil C
- Re-invigorates C uptake by vegetation regrowth
- Results in storage of ‘black carbon’ in soils
Daily net ecosystem productivity (NEP) at the pine flatwood site over 6 years of measurements.
Pre-fire: 900 g C m$^{-2}$
Immediately post-fire: 60 g C m$^{-2}$
Carbon Storage and Dynamics at Disney Wilderness Preserve

(Becker and Hinkle, 2018)

NEE as CO₂
CH₄
ET

Aboveground Biomass Carbon (kg C/m²)

Scrubby Flatwoods 1.31 (±0.47)
Longleaf Pine Flatwoods 2.27 (±0.63)

Pasture in Restoration 0.43 (±0.06)
Un-restored Pasture 0.27 (±0.14)
Slash Pine Flatwoods 1.90 (±0.54)

Wetland Ecosystems
Bay Swamp, Cypress Swamp, Seepage/Depression Marshes

0-90 cm

Litter Carbon (kg C/m²) 0.17 (±0.05)
Root Biomass (kg C/m²) 3.7 (± 0.5) (Bain and Day 2017)
Soil Carbon (kg C/m²) 5.0 (±1.2)
Soil Order Spodosols/Entisols Spodosols Spodosols Spodosols Spodosols/Alfisols Spodosols/Histosols

Bay Swamp = 34.3
Cypress Swamp = 23.4
Marsh = 20.1 (Huber and Bohlen 2017)
Major finding so far at DWP and BCM

- Fire and hydrology are major drivers in carbon dynamics across this landscape.
- Systems prone to fire have a rapid recovery from a temporary source to a sink and the above ground biomass recovered in 3 years in Pine Flatwoods.
- Seasonal, annual and spatial gradients in hydrology regulate fluxes of CO$_2$ and CH$_4$.
- All sites were shown to be a sink for CO$_2$ and thus provide an important carbon storage function.
- Greenhouse gas contributions of methane emissions from the wetland sites have somewhat offset CO$_2$ sequestration of the landscape.
Thanks for your attention!
**Table 1: Response of fluxes to hydroperiod**
Annual sums of net ecosystem exchange of CO$_2$ (NEE), methane flux and the number of days when water level was below land surface for the Blue Cypress Marsh site.

*modeled data*

<table>
<thead>
<tr>
<th>Year</th>
<th>NEE (g C m$^{-2}$)</th>
<th>CH$_4$ flux</th>
<th>Stage&lt;0</th>
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<tr>
<td>2010</td>
<td>-597</td>
<td>33*</td>
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<tr>
<td>2011</td>
<td>-65</td>
<td>26*</td>
<td>104</td>
</tr>
<tr>
<td>2012</td>
<td>-97</td>
<td>32*</td>
<td>71</td>
</tr>
<tr>
<td>2013</td>
<td>-284</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>-290</td>
<td>26</td>
<td>40</td>
</tr>
</tbody>
</table>

**Table 2: Site comparison Net ecosystem exchange of CO$_2$ and methane flux all sites over a 1-year comparison period in 2013-2014**

<table>
<thead>
<tr>
<th>Site</th>
<th>NEE (g C m$^{-2}$)</th>
<th>CH$_4$ flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Cypress peat marsh</td>
<td>-177</td>
<td>38</td>
</tr>
<tr>
<td>depression marsh</td>
<td>-131</td>
<td>66</td>
</tr>
<tr>
<td>pine flatwoods</td>
<td>-96</td>
<td>-</td>
</tr>
</tbody>
</table>